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SCHOOL BUILDINGS, GROUNDS, EQUIPMENT, APPARATUS, AND SUPPLIES

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Volume II **December, 1932** **Number 5**

School Buildings. Grounds, Equipment, Apparatus, and Supplies

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Table of Contents

FOREWORD

It is not difficult to show the great importance of research upon the problems connected with school buildings. Research contributes to all aspects of the planning and construction of school buildings and of school grounds. The correct location of buildings and grounds demands research into population trends and into the specific character of the various sections of the community. In planning buildings, costs must be weighed in relation to beauty and utility. The arrangement of the building must be made subservient to the educational functions which are to be performed. The building must be planned with reference to the health and safety of the pupils.

All these matters may be dealt with by a rule-of-thumb procedure which has grown up by the gradual accretion of tradition based chiefly on judgment, or on very partial or incomplete research. Such practice is not worthy of modern education. It is likely to be both expensive and ineffective. The alternative method is to study the problems by means of the most advanced scientific technics which are available. The revolutionary findings of the New York Commission on Ventilation is but one of a number of examples which indicate the necessity of careful scrutiny of our practices and of penetrating research into all traditional procedure.

Frank N. Freeman,
Chairman of the Editorial Board.

INTRODUCTION

THE original plan of this *Review* contained four headings—school buildings, grounds, equipment, and supplies. The committee after considering the problem, concluded that since the school building survey has become such an important factor in the housing of pupils, some attention should be devoted to its technics. A separate chapter has, therefore, been prepared on the school survey.

Because of the wide differences in practice in defining equipment, apparatus, and supplies, mention is here made of the definitions used in this study. *Equipment* has been defined as all fixed and movable furnishings having a normal life exceeding two years. The definition of *supplies* is the one generally accepted by the National Association of Public School Business Officials; that is, all those items in school use which are either used up immediately for instructional purposes or whose life is very short. *Apparatus,* as used here, refers to anything used in the school for instructional purposes that is not classified as supplies, such as maps, charts, laboratory materials, etc. Strictly speaking, most apparatus can be included under the definition of equipment; but since the classification is still commonly used in science catalogs, inventories, etc., it has been included in this study.

Attention is also directed to certain duplications in the different chapters. For example, Chapter I includes a section on school building score cards, as also does Chapter III. Both of them, however, have been included because in each case the section is really a part of both chapters; and, since some readers may use only a single chapter, each chapter should be fairly complete.

T. C. HOLY, *Chairman,*
Committee on School Buildings, Grounds, Equipment, Apparatus, and Supplies.

CHAPTER I

The Survey Preliminary to a School Building Program

INTRODUCTION

THIS chapter deals with the preliminary survey which is necessary in the formulation of a school building program. According to Engelhardt and Engelhardt (25:519):

> A survey involves research, an interpretation of the facts discovered, and the planning of a program in the light of the facts.

According to Sears (66:1):

> The term has been used more or less loosely, but in general it has been applied to careful, factual studies of educational conditions and results together with constructive criticisms of the findings.

Engelhardt and Engelhardt (25:519) cited Caswell as defining a survey in its strictest sense thus:

> A study conducted by outside authorities and designed to measure the adequacy of past and present procedures, or to formulate plans for the future, or both.

Caswell (9:25-26) applying four criteria—conduct of the survey by an agency outside the regular school system, publication of the survey, a study not incidental to another kind of survey, and the primary purpose the betterment of the local school system—dated the first survey as of 1910 with increasing numbers year by year. He (9:31) listed the following agencies: individual investigators, special survey commissions, foundations and bureaus of research, the United States Bureau of Education and state departments of education, and organizations in colleges and universities with the definite function of making surveys.

Scope of the Survey

Caswell (9:87) gave the following items: (1) present plant, including appraisal and utilization; (2) educational program in relation to buildings; (3) future building needs, including population trends and residential development; (4) a building program with definite steps of development; (5) financing the building program.

Sears (66:116-118) suggested the following: (1) definition of educational needs; (2) efficiency of present facilities; (3) ability of the city to meet its educational needs; (4) constructive proposals including (a) the extent to which present needs are being met, (b) appraisal of the present

policy, (c) present and future needs, (d) appraisal of the city's financial ability to meet these needs; (5) financial plan best suited to the conditions of the city.

Moehlman (49:120) outlined the following topics in a survey necessary to the scientific development of a school plant: (1) survey organization; (2) economic and social character of the community; (3) possibilities of growth; (4) determination of community educational responsibility; (5) educational organization; (6) educational designing; (7) architectural service; (8) analysis of present plant; (9) determination of the ultimate plant; (10) preparation of the program of achievement; (11) preparation of the financial program; (12) organization of report; (13) review and decision by the board of education; (14) organization of the problem of public relations; (15) administration of program; (16) appraisal of program.

Smith (67:297-329) suggested the following steps: (1) character of the city involving a detailed study of its population; (2) educational program; (3) policy of school organization; (4) status of present school plant with reference to its usability in the light of the educational program outlined; (5) ultimate school plant; (6) ability of the community to finance the school program.

From the foregoing it will be noted that there is general agreement that a school building survey should include as a minimum the following: (1) character of the community, including detailed study of the population and its activities; (2) school population, including its increase and persistence in school; (3) appraisal of the existing school plant, including its utilization for educational activities and its possible utilization in any building program proposed; (4) community educational program and plan of educational organization; (5) ultimate plan proposed; (6) capacity of the community to finance the program. Beginning on page 348, the present chapter follows this outline.

Appraisal of Survey

Caswell made the most extended available study of the results of surveys. He said (9:73):

> The contribution of the survey movement to the development of technics of school plant evaluation and planning is one of the outstanding features of survey development.

After a study of fifty surveyed cities, he found that 50 percent adopted a definite building program, 55 percent adopted a policy of purchasing larger school sites, 50 percent actually purchased larger school sites, 71 percent erected buildings in accordance with plans outlined in survey, 84 percent remodeled buildings recommended for remodeling in the survey, 65 percent abandoned buildings so recommended in the survey, 67 percent remodeled ventilating systems, 47 percent improved lighting, 40 percent increased the size of school buildings, and 43 percent enlarged administra-

tive offices. He stated further that in twenty cities in which specialized building surveys were made the changes due to the survey were even more marked than in the fifty cities having had general surveys. On the basis of the criteria suggested above, Caswell (9:110-119) listed 194 surveys published between 1910 and 1927 that fulfilled these requirements.

Cost of Surveys

Caswell (9:46-49) found that the cost of sixty-four surveys varied with the size of the city, but averaged approximately $1,000 for cities with a population up to 10,000, approximately $3,000 for cities of 10,000 to 50,000, approximately $9,000 for cities of 50,000 to 100,000, and approximately $9,000 for cities of more than 100,000. Payment was made in 87 percent of the cases by the board of education or the city council.

1. CHARACTER OF THE COMMUNITY

Moehlman (49:52) indicated that an analysis of the character of the community involves study of type of population, racial composition, social conditions, rate of growth, economic development, and future industrial development. In types he recognized rural, industrial, residential, mining, commercial, mixed, and metropolitan.

Measurement of General Population Growth

Holy (41:93) recognized two factors in the growth of a city: increase in density of population and expansion of corporate limits. Engelhardt and Engelhardt (25:12) recognized four basic causes for change in population: natural increase, immigration, emigration, and combinations of these. They also recognized three types of growth in communities: regressive or static, fair degree of regularity of growth, and rapid development. The natural growth of population is the excess of births over deaths, but the rates of each may vary. They (25:27) called attention to the fact that persons between the ages of twenty and forty move about most freely, thus contributing to population changes by immigration and emigration.

A forecast of population is imperative in order to plan a building program. Engelhardt and Engelhardt (25:54-71) recognized the following technics of population forecast: personal judgment, either individual or group, which they characterized as little more than "booster" technic; analogy, or comparison with similar but older cities; economic factors; mathematical methods; and the method of index analysis. Of analogy they said that the similarity is more a coincidence than a specific anticipatory trait relating economic change to population. They discovered no direct relationship among economic data and indicated that there is lack of synchronization.

Chamberlain and Crawford (10:10-15) summarized the methods used in fifty surveys and suggested five categories: predictions based wholly on past census figures, the Bell Telephone Company's method of index analysis, the equation method, the multiple factor method, and a combination method which is based on the varied results of the application of two or more methods.

The same study compared the total population forecasts for 1930 in twenty-two cities, made on the basis of predictions based wholly on past census figures, with actual populations of these cities for 1930. They found that the mean error is 13.98 percent, the maximum error, 62.81 percent, the minimum error, .3 percent, and the weighted mean of errors, 19.05 percent. Predictions over-estimated the population in approximately 77 percent of the cases and under-estimated the population in approximately 23 percent of the cases.

The Bell Telephone Company technic or index analysis method was described by Engelhardt and Engelhardt (25:69-71) and was applied by F. Engelhardt (24:22-25) to schools. It was also described by Sterns (69: 22-29).

Chamberlain and Crawford (10:16-18) compared the populations predicted for 1930 by the Bell Telephone Company with the actual 1930 populations for ten community areas. The mean error was 6.44 percent, the maximum error, 13.89 percent, the minimum error, .97 percent, and the weighted mean of errors, 7.92 percent. In 60 percent of the cases the population was over-estimated. They then compared the total population forecasts for 1930 of ten school surveys using the method of index analysis with actual populations for 1930. The mean error was 11.63 percent, the maximum error, 33.94 percent, the minimum error, 1.08 percent, and the weighted mean of errors, 16.58 percent. The population was over-estimated in 80 percent of the cases.

The equation method refers to the mathematical formula developed by Pearl and Reed, which was described and applied to schools by F. Engelhardt (24:29-50). Moehlman (49:382-383) reproduced the growth curve which is fully developed by Pearl (59:1-24). With this equation Pearl believed that population can be predicted accurately for a ten to twenty-year period, but added that longer range predictions could be taken seriously only by someone who denied the fact of evolution.

Chamberlain and Crawford (10:18) compared the total population forecasts for 1930, made by the equation method for five cities, with actual populations for 1930. The mean error was 15.18 percent, the maximum error, 38.07 percent, the minimum error, 2.17 percent, and the weighted mean of errors, 19.41 percent. The population was over-estimated in 60 percent of the cases.

The multiple factor method was described in some detail by Strayer and N. L. Engelhardt (74:325-29) and by Engelhardt and Engelhardt (25:

77-78). It assumes that many quantitative factors of a social and economic character are related to increase in population. Engelhardt and Engelhardt showed that there is no proof of the accuracy of the basic assumptions underlying this method. Again, Chamberlain and Crawford (10:18, 19) compared the total population forecasts by this method for eight cities for 1930 with the actual populations for 1930. They found the mean error to be 38.57 percent, the maximum error, 115.37 percent, the minimum error, 5.93 percent, and the weighted mean of errors, 50.63 percent. The population was over-estimated in every case. The same writers then combined the fifty-eight cases studied in a single table, and showed that the mean error of prediction was 17.70 percent, while the weighted mean of errors was 26.68 percent. The population was over-estimated in approximately 79 percent of the cases.

Chamberlain and Crawford (10:19) commented as follows concerning the technic of the Bell Telephone Company:

> Population forecasts based on data furnished by the Bell Telephone Company have been, in general, characterized by the smallest error of prediction, with a mean error of 11.63 percent and a weighted mean of 16.58 percent.

The multiple factor method appears to them, from the data used, to have been the least accurate (10:26). They (10:20) quoted a study by G. C. Hauser which indicated that engineers' estimates have proved too high in approximately the same proportion of cases over a period of thirty-five years. They felt that variations in reliability, which are apparent through using the different methods, are not significantly related to different lengths of period covered by the predictions.

In addition to the foregoing, F. Engelhardt (21:27-28) and Moehlman (49:331) described the geometric progression method. The assumption underlying this method is contrary to the basic assumptions of the Pearl-Reed Equation as given by Engelhardt (21:30):

> Since population lives upon limited areas, there must be a definite upper limit to the number of persons who can live on that area; that is, it is not conceivable that populations on particular areas can increase without limit. . . . The rate of growth during each epoch, in so far as it has been observed, varies, being slow at first, then increasing in rate to maximum and then decreasing until almost a stationary aggregate of population is maintained.

The arithmetic progression method was described by Engelhardt (21: 28). This method also disregards the basic assumptions underlying the Pearl-Reed Equation given above but to a smaller degree than prediction by geometric progression.

Carver's application of the Gompertz curve was described by Moehlman (49:376-381). The Courtis application of the Gompertz curve was also described by Moehlman (49:382) and by Courtis (14). Of the theory underlying this curve, Courtis (14:353-54) said that all biological growth, in which there is progress toward a defined maturity produced by constant

nurture acting on constant nature, has a period of rapid acceleration, a period of relatively constant progress, and a period of rapid retardation.

Holy (41:93-96) used four methods of population prediction in the Survey of Charleston, West Virginia: the Link relative method based on average relative increase from decade to decade; the anti-logarithmic method; the straight line regression; and the ratio between total population and school enrolment. The average of these is taken as the predicted population.

Moehlman (49:371-375) described a field survey method. He determined a saturation point assuming a continuation of existing conditions.

Moehlman (49:73), however, issued a word of warning in connection with all population prediction methods:

> Every estimate of future population must be based upon the continuation of existing conditions, and these conditions may change rapidly.

He then listed thirteen conditions, changes in which may affect the population. Among these are types of industry, development of new industries, influence of inventions, variability in public tastes, standard of living, deliberate limitation of family size, birthrate, and deathrate.

Racial and Social Composition of General Population

Engelhardt and Engelhardt (25:20-25) contended that racial composition is an important educational factor, particularly in those cities having a large colored population and segregated schools. Mere percentage of foreign born alone does not define the problem. The type of foreign born is significant as is also their segregation. Moehlman (49:324-25) studied size of family by nationality using forty-two national groups. He found that eastern and southern European families are the largest, while American white families are significantly smaller. Commenting on this, Moehlman (49:64) said:

> An analysis of population by nationality elements indicates a rather close relationship between nationality and size of family, nationality and physical development, nationality and housing conditions, and nationality and length of time spent in school in terms of grade classification.

Moehlman (49:327) also used a technic for studying housing conditions in which he classified houses as owned and rented, and then under each category he listed singles, flats, and apartments.

General Population Density and the Saturation Point

Percentage of saturation was defined by Strayer and N. L. Engelhardt (78:228) as the ratio of number of lots built upon to the total number of lots of same size and type which will completely fill the block. This was applied to establish certain trends when these ratios were taken for a period of years.

Engelhardt and Engelhardt (25:112) pointed out that population density varies with type of dwelling, birthrate, economic status of the people, and other factors. Density changes over a period of years, according to Moehlman (49:76-77). It may be measured by the lot occupancy as was done in the Pasadena Survey (7:283-285), and in the Cleveland Heights study described by Engelhardt and Engelhardt (25:186). O'Brien (57:56, 58) used it in the Lawrence Survey.

A technic of studying migration was developed by F. Englehardt (22: 8, 9). By a study of the families moving in each year, in addition to those already resident, he determined the children in each age group for a period of years. Moehlman (49:76-77) showed that density changes over a period of years and territorial growth are factors affecting saturation.

Materials To Be Used

Engelhardt and Engelhardt (25:155) suggested bird's-eye views, aerial photographs, and government maps including topographic, base, and contour. Spot maps are used frequently to show various factors, including population density.

2. SCHOOL POPULATION

A separate study of the forecast of school population is necessary. Engelhardt and Engelhardt (25:2) said:

> It frequently happens that school population changes do not synchronize with total population modifications or with economic changes. . . . The nature of the change may not be identical.

They (25:37) asserted further that the ratio between the total population and the five- to fourteen-year-old group varies in cities of the same total population, showing that the range in cities of 25,000 and over is from 12 to 23 percent in this group. They showed further that the proportion of the total population registered in the public schools varies in cities and states and also in cities of the same size.

Moehlman (49:79) pointed out that the relationship between school census and the total population varies generally from 35 percent to 25 percent. He believed that in general the school census tends to form a larger proportion of the population in newer and rapidly growing communities than in older and more settled communities.

The measures of school population suggested by Engelhardt and Engelhardt (25:30-37) are school census, net and gross enrolment, attendance, proportion in private and parochial schools, and transfers to and from the foregoing types of schools. The school population, they observed, is increased or decreased by children reaching school age, deaths, withdrawals, graduation, and transfers.

They (25:51) also emphasized the necessity of proper child accounting records so that the recorded information may be comparable. Moehlman

(49:82-90) likewise insisted upon accurate records including a continuing school census, membership over a period of years in various types of schools, the relationship of school membership to school census with trends over a long period of time, the composition of school membership by grades, and age-grade surveys. The work of recent writers in the field of child accounting was stressed by Engelhardt and Engelhardt (25:51)—particularly that of Emmons (20), Ganders (31), Heck (35), and Moehlman (47). To these may be added McAllister and Otis (46) and the reports of the National Education Association's Committee on Uniform Records and Reports (54, 55).

F. Engelhardt summarized the records needed in the Robbinsdale (22: 41, 42) and Albert Lea (24:12, 13) Surveys, and listed the permanent summary records to be kept on file in the office of the superintendent, on the basis of which facts can be recapitulated and analyzed each year. He mentioned specifically census of school children, housing conditions, family factors, school records giving number of children leaving school for various causes, enrolment totals, new entrants, and transfers. Under each heading he provided a detailed classification.

Methods of Forecasting School Population and Enrolment

According to Chamberlain and Crawford (10:21) the chief methods used in forecasting school enrolments are forecasting school enrolment from total population, forecasting by analysis, forecasting by mathematical technics, the Bell Telephone Company's method, multiple factor method, and forecasting by analogy. They pointed out further that a study of the surveys showed that practically all committees have employed either the first method, or some modification of it, or the analysis method. Seldom has the multiple factor method or the mathematical method been used. They compared thirty-five school enrolment forecasts for 1930-31 with actual school enrolments for that year. They reported a mean error of 8.66 percent, a maximum error of 27.15 percent, and a minimum error of .24 percent, with a weighted mean of errors of 11.49 percent. The school enrolment was over-estimated in approximately 54 percent of the cases.

The same students in a comparison of eighteen predictions, based on the relation of the school enrolment to the total population, with the actual school enrolments for 1930-31, showed a mean error of 8.11 percent, a maximum error of 27.15 percent, a minimum error of .58 percent, and a weighted mean of errors of 11.18 percent. Finally they made a comparison of thirteen estimates by the method of analysis with actual school enrolments in the school year 1930-31. The mean error was 9.25 percent, the maximum error, 22.80 percent, the minimum error, .24 percent, and the weighted mean of errors, 12.02 percent. The mean gross error for fifty predicted total populations expressed in percent was 16.96. In about 76 percent of the total predictions the population was over-estimated. They (10:27) concluded:

. . . It would appear from this investigation that simple and direct means for predicting school enrolments should, in the future, be substituted for time consuming procedures of a technical nature until the superiority of such procedures can be definitely demonstrated. Furthermore, it seems probable that a direct analysis of school facts, with only incidental attention to total population trends, promises the best basis for school predictions. Finally, the difficulty of accurate prediction under any circumstance must be recognized, and original estimates must be promptly and continuously altered in terms of newly discovered facts.

Although it is frequently assumed that the ratio of school census population to school population is constant, Engelhardt and Engelhardt (25:75) asserted that this does not constitute a true measure of those for whom facilities must be provided. They pointed out (25:45) that a decreasing birthrate between 1920-28 was indicated in the elementary enrolment in certain parts of the country; and they predicted, during the decade 1930-40, a general falling off in the rate of increase in elementary-school enrolment, unless this change is offset by increases in the number of kindergartens and nursery schools.

Phillips (62:7) showed that the birthrate declined from 25.6 percent in 1913 to 24.6 percent in 1918 and then to 22.3 percent in 1919. In 1922 it rose to 22.5 percent and then grew smaller each year, reaching 19.7 percent in 1928. He showed also that the first-grade enrolment in 1926 dropped below four million for the first time since 1913. He declared it probable that the reduction in immigration accounted for less than one-half of one percent of the loss recorded in the early grades in recent years. From these facts it is obviously unsafe to assume that in any community the ratio between school census and total population will remain constant. Moehlman (49:79) said:

Since 1890 the United States census returns show a steady decline in the proportion of school census to school population. Studies in individual states and cities indicate that this same tendency holds true.

This argues against the prediction of total population by the use of the ratio of children to families in each school district.

3. APPRAISAL OF THE EXISTING SCHOOL PLANT

The appraisal of the existing school plant involves (1) an evaluation of that plant on the basis of standards generally accepted; (2) a study of the utilization of its facilities in the administration of the educational program of the community; and (3) the determination of the availability of its units in the future or ultimate school plant of the community.

Standards for Appraisal

Standards widely accepted have been set up for different types of school plants and for component parts of the plants. Many of them are the result of extended, often exhaustive, studies. Among the standards applicable to

school plants without specific reference to the type are those set up by the National Education Association Committee on Schoolhouse Planning (13), by Dresslar (17), by Donovan (16), and by Hart (34). The so-called "Candle of Ratios," developed by Cooper and his committee (13:57-73), gave a measure of the relative efficiency of buildings in the allotment of floor area to six factors, *viz.*, stairs and corridors, administration, walls and partitions, flues, accessories, and instruction. Moehlman (49:127-131) used a ratio between volume and shell area which he called *envelope efficiency*, and one between instructional area and total area which he designated *instructional space efficiency*. The product of these ratios gives the *instructional-space-envelope efficiency* on the basis of which comparisons may be made.

There are, in addition, standards that apply to specific types of buildings. For secondary schools Strayer and N. L. Engelhardt developed standards for both senior high schools (88) and junior high schools (27). Holy and Arnold (40) also developed standards for junior high-school buildings using judgments of junior high-school principals, school architects, and school building specialists as the basis. The Commission on the Reorganization of Secondary Education (53) prepared a statement of standards applicable to high-school buildings. Standards for elementary-school buildings of several rooms were developed by Strayer and N. L. Engelhardt (87). Standards for small school buildings, including rural plants, were devised by Strayer and N. L. Engelhardt (90), by Dresslar and Pruett (18), and by Butterworth (6). Strayer, N. L. Engelhardt, and Elsbree (89) formulated standards for administration buildings.

In addition to these standards covering the plant as a whole, standards have been developed for specific provisions within the school plant. The New York Commission on Ventilation (56), which had been engaged in a series of experiments extending over a period of eighteen years, has submitted its final report. Their findings are so much at variance with some of the previously developed standards that they suggest new laws replacing statutes at present in force in several states (56:58-65). Thomas (91) developed standards for plumbing equipment; Ford (30:25-60), for the high-school cafeteria; M. Smith (68:42-76), for the school theater; and Brodshaug (3:37-115), for home economics rooms.

State Regulation

In recent decades the various states have extended their control over the housing of public-school children. Cooper (13:85-89) showed that twenty-four states had no regulations on schoolhouse planning or construction in force in 1910, but by 1920 only four remained without some sort of regulation; that between 1915 and 1920 the state regulations in force had increased from 442 to 1,147. Within the same period the number of state departments of education, to which were delegated responsibility for some

sort of supervision, increased from thirteen to thirty-six, and the state departments of health from nine to twenty-one. Data on state architects and special inspectors were not available for 1910, but by 1920 the number to whom some responsibility was delegated was five and seventeen respectively. Engelhardt and Engelhardt (25:297-302) showed, for the same period, an increasing supervisory control over structural items. They also pointed out variations existing in state regulations in the requirements affecting floor area and cubage per occupant; ratio of glass area to floor area, which varies from 14.3 percent to 25 percent; and ratio of occupants to different types of toilet fixtures. They warned against too great standardization and the enacting into statutes of too many specific items. They (25: 549-59) also summarized briefly for each state the character and extent of its participation and cooperation in the planning and erecting of school buildings.

School Building Score Cards

The school building score card has been devised to enable a trained worker to apply standards to a school plant objectively. The score card usually provides for the scoring of a school plant on the basis of 1000 points allocated by a composite of expert judgments among a limited number of major headings. Each of these is then divided and subdivided, resulting in a large number of individual items, each with its definitely assigned portion of the 1000 points. As the building is scored, each of these items receives at the hands of the scorer a rating ranging from zero to the maximum allotted. The specific amount depends on the degree in which, in the judgment of the scorer, the item under consideration meets the requirements set up in the standards.

For purposes of appraisal Strayer and Engelhardt devised score cards for elementary-school buildings (82), junior high-school buildings (84), high-school buildings (83), and village- and rural-school buildings of four teachers or less (86). Holy and Arnold (40) recently developed a score card for junior high-school buildings. Strayer, N. L. Engelhardt, and Elsbree (85) devised a score card for the administration building of a school system. Butterworth (5, 6) developed a score card for one- and two-teacher buildings. Holton and Strickland (36) developed one for rural schools. Stevenson and Ashbaugh (71) developed score cards for one-teacher rural-school buildings, and Stevenson (70) for elementary-school buildings. Others whose scoring devices have been more or less widely used are Almack (1), Dick (15), and Schmidt (65).

In 1921 a committee under the chairmanship of Strayer (52) reported the results of a nation-wide cooperative study of school housing involving reports from 429 out of 950 cities with a population of 8,000 and above. He called attention at that time to the increasing attendance and the liability of congestion. The median or typical elementary-school building he

characterized as one built in 1897, two stories high, with ten rooms, attended by four hundred children, each child having 34 square feet of playground space. The structure with brick walls, but otherwise of mill construction, was a fire trap (52:42, 43). Holy (41:16-20) grouped 7,067 West Virginia school buildings according to the classes of the American Institute of Architects. He then ranked fifty-five counties of that state according to the Ayres Index and computed the correlation between the two. By the Pearson Product-Moment Formula the correlation was $+.66 \pm .053$. Furthermore, the county having the highest rank had the smallest percentage of class E buildings, and the one having the lowest rank had the highest percentage of buildings of that type.

Utilization of Plant

Morphet (50) made an extended study of school building utilization and devised with Strayer and N. L. Engelhardt (80) a suitable form to be used in the study of a specific building. He (50:18) used two types of measures, *room utilization*, which is concerned with the question of whether rooms are used or not; and *pupil station utilization*, which is concerned with the relation between the number of pupils using a room and the number of pupil stations in the room. To these Moehlman (49:150-51) added another measure, *absolute capacity*, which is pupil capacity in terms of floor area or cubage per occupant. This apparently is similar to the 100 percent utilization as used by Morphet (50:18).

Studies of utilization—Morphet (50:33-48) made a room utilization study of fifty-eight buildings. He found an average of 80 percent utilization of all rooms except auditorium, gymnasium, and cafeteria on the basis of class periods, 71.6 percent on the basis of all periods in schedule, and 53.5 percent on the basis of a 2,400 minute week. Including all rooms the percentages are 75.4; 68.7; and 51.8 respectively. He then studied the pupil station utilization in the same schools. This he found to be greatly influenced by the size of auditorium and cafeteria and the use made of these rooms. The percentage of pupil station utilization for these buildings without the above rooms for class periods, he found to be only 58.8 percent; for all periods using present equipment 53.3 percent; and for all periods using maximum equipment 51.4 percent. Corresponding percentages, including auditorium, gymnasium, and cafeteria, were 41.1 percent, 38.2 percent, and 37.9 percent respectively. He also computed the percentages of utilization of different types of rooms. He showed that the percentage of utilization based on class periods is higher than on any other basis. He (50:100) concluded that the probable maximum pupil station utilization will be much less than 100 percent for each type of room, and will seldom exceed 70 percent for the entire building.

Lewis (45) reported a utilization study of a high-school building on these two bases and concluded that a 100 percent utilization is impossible;

that 80 percent constitutes a reasonable use. The Pasadena Survey (7:310) cited a study by Gardner W. Spring of the University of California of thirty-eight California high schools. The rooms were classed as academic, commercial, science, music, shops, art, and home economics. The range of the median percentage of utilization varied from 27 percent for music to 55 percent for shop. The range of 75 percentile points was from 36 percent for music to 76 percent for shop. This study took 90 percent as a reasonable working capacity, recognizing that it would be administratively impossible to have every seat occupied continuously. Holy (42:48) suggested a division into academic and non-academic rooms, with a separate utilization study of each group.

Engelhardt and Engelhardt (25:283-92) reported a case study for the utilization of the high-school plants in Superior, Wisconsin, in which they showed the necessity of careful planning to coordinate the facilities of two plants rendering the same type of service, and of efficient internal administration. They (25:279-82) also showed in four junior high schools similarly planned, the variations which may result from variations in the administration of the curriculum. They (25:266) listed five factors which may materially affect utilization, *viz.*, capacity of study hall, home rooms, library, basement rooms, and special rooms not designed for multiple use.

Disposing of Existing Plant

Moehlman (48) classified existing units into four categories: those which fit into ultimate plant without change; those which fit into ultimate plant with modifications of site and building, those which can be used for some years but not indefinitely, those which should be abandoned immediately. N. L. Engelhardt (26:57) characterized buildings scoring below five hundred as highly unsuited to school purposes in a modern sense and recommended their abandonment. Those scoring between five hundred and six hundred might, with extensive repairs, be reasonably habitable. Moehlman suggested (49:124-26) that operation and maintenance costs are also criteria. When the annual upkeep is as much as 5 percent of the original cost, retention is debatable; and when it reaches a figure as high as 10 percent, the buildings should be abandoned.

4. THE PLAN OF ORGANIZATION AND EDUCATIONAL ASPECTS

Sears wrote of these aspects (66:115, 124):

> A school building program then must be written in terms of educational needs, and our measure of the efficiency of any plant as it exists must be in terms of the extent to which the plant is meeting the demands of a satisfactory educational program. . . . Once the objectives are clearly conceived, and the plan of organization and the general character of the curriculum decided upon, it is then possible to work out the types of buildings needed.

Moehlman (49:100) suggested that planning is inherently an instructional activity. He (49:98) further suggested that there may be no provision for such planning, or dependence may be placed on the architect, or on a specialist in the employment of the architect, or on an outside specialist, or on the executive organization of the school system.

A matter of paramount importance is the type of school organization (25:344). The trend toward the 6-6 or 6-3-3 type of organization was shown by Phillips (61:3), who pointed out that the cities over ten thousand adopting the junior high school increased during the period 1917-26 from 123 to 383 and the number of junior high schools, from 259 to 980. Packer showed (58:55) the effect of the adoption of a policy of organization on the Detroit City School System, where the proposed types were reduced from 20 to 3.

5. THE ULTIMATE SCHOOL PLANT

Moehlman (49:171) outlined four major problems in the achievement of the ultimate school plant: possible future plant requirements, best disposal of present plant, best location of new centers for present or future needs, and determination of rate of achievement.

Engelhardt and Engelhardt (25:200) pointed out that "the city plan and the school building program ought to dovetail." Among the factors involved (25:201-11) they listed the classification of property, zoning, and regional plans as important in the development of the school plant and plan in harmony with the city plan.

The specific location of each plant of the various types will be determined by the policy of spacing adopted. The spacing in turn is dependent upon travel distances adopted, density of population, and size of building desired. The size of building is affected in some measure by the attitude toward class size.

Travel Distances

The National Education Association Committee on Schoolhouse Planning (13:14) suggested as reasonable a contributing area for elementary-school districts having a radius of ½ to ¾ of a mile; for junior high schools, one of 1¼ to 1½ miles; and for senior high schools, one of 1½ to 2 miles. Widely accepted standards for walking distances are those quoted by N. L. Engelhardt (26: 53) from Spaulding, *viz.*, a maximum for kindergarten and elementary-school pupils of not more than 1 mile; for junior high-school pupils of not more than 1½ miles; and for high-school pupils of not more than 2 miles.

Holy (37) showed, as the result of an analysis of the actual traveling distance of more than six thousand elementary-school children living within a ½ mile radius from elementary schools, that 74.5 percent traveled less than ½ mile to reach the school; 21.5 percent traveled between ½ and ⅝

mile; 4 percent, between ⅝ and ¾ mile; but no child was required to travel in excess of ¾ mile. Engelhardt and Engelhardt (25: 107-109) reported the results of a study of the judgments of parents relative to desirable walking distances. Fifty percent felt that ½ mile or eight short city blocks was the maximum distance, and but 6 percent placed the maximum at a mile or more. It was also found that over 90 percent of the children in various elementary grades required less than fifteen minutes to walk to school. Fifty-four percent of the junior high pupils were able to walk to school in less than fifteen minutes. The same report (25:110) showed that 64 percent of the children in a Minneapolis elementary school traveled less than eight city blocks, and 73 percent of the junior high-school pupils traveled less than sixteen blocks (approximately one mile).

Population Density

Engelhardt, Hegel, and Womrath (22: 44-45; 23; 25: 176-186; 92: 17-29) developed a method of calculating population indices on the basis of which the number of pupils which might be produced by a given district can be prognosticated. "Unit area" maps of the city are constructed. The number of children per 100,000 square feet of area is used as a unit in measuring the density of school population. Indices per unit of area are then calculated for both public and private elementary, junior high, and senior high-school pupils. A comparison of the various indices of similar areas not fully occupied with the indices of similar areas fully occupied, then, reveals the school population of various types to be expected. Engelhardt and Engelhardt (25: 183) pointed out, however, that due to uncontrolled variables a periodic check is necessary.

Size of Building

The policy adopted in regard to class size will affect the number of rooms required in a building. Stevenson (72) has shown both for elementary schools and for high schools, that the differences in instructional efficiency, as measured by the usual educational achievement tests, between large and small classes are so small as to be practically negligible.

Once the maximum size of class has been determined, the size of building may be determined by other factors. Moehlman (49:36) insisted that the number of buildings for each type of school should be as few as possible, and questioned the economy or instructional efficiency of any plant accommodating fewer than eight hundred pupils. He (49: 133) favored eight hundred as a minimum, fourteen hundred as a mean, and twenty-four hundred as a maximum. The Detroit instructional program showed that the most efficient use of rooms, equipment, and specialized personnel was reached with a twenty-one hundred membership (49: 136).

Dudley (19: 45) found the optimum size of junior high school based on economic use of special rooms ranges from twelve hundred to twenty-five

hundred pupils. He (19: 47) felt, however, that for the senior high-school, no optimum size could be given.

There are some pertinent data relative to unit costs in plants of various sizes. Dudley (19: 40) showed that total operation costs in comparable schools for a three-year period in Newark, New Jersey, decreased rapidly as the capacity of schools increased up to seven hundred. Above this he found little change up to seventeen hundred.

Strayer and N. L. Engelhardt reported several studies showing unit costs in contrast with building size. In Springfield, Massachusetts, they (76: 120-25) reported the cost for total current expenses per pupil increased very rapidly as the average attendance became less than two hundred and fifty. The sharpest increase in cost per pupil in average daily attendance occurred in schools having fewer than one hundred and twenty pupils. The data for Providence, Rhode Island (75: 196-201), are similar. In that study operation expense per child increased rapidly as the enrolment fell below four hundred. Below two hundred the line of the cost curve rose almost vertically. The curve was practically level after five hundred, both for current expense as a whole and for instructional service. For operation it rose at five hundred, but the rise was not significant. Ford (29: 28) showed that the decrease in per pupil cost with increase in size of high school is not significant after an enrolment of three hundred is reached. But he held that schools may become too large; "when personality is lost in numbers, the educational process is very likely to suffer."

Instruments for Spacing

Moehlman (49: 140) suggested five methods of locating school districts and school plants, *viz.*, circle, square, staggered square, diamond, and irregular square. Engelhardt and Engelhardt (25: 157) suggested the circle, but mentioned also the square circumscribed about the circle, citing Goodrich and Lefler (32: 67).

6. THE PROGRAM OF FINANCE

The final question which the preliminary survey must answer is the ability of the community to finance a building program. Moehlman listed (49: 201) three factors: expense of program, financial ability of the community, and method of raising funds to meet the expense. He (49:94-95) pointed out that the real ability to pay is dependent in part at least on "the extent to which they desire to make further sacrifice to satisfy the felt need.

Determining Expense of Program

A study of the trends in material and labor costs and in interest rates are essential to any adequate estimate of the expense involved in carrying out a building program. Burgess (4:88-106) studied the trends of building costs between 1840 and 1920 using building material prices and wages

paid artisans. His indices are much more complete after 1913 than prior to that date. More recently Clark furnished indices of bond prices and building costs on the basis of which comparisons can be made and both the material and the bond market watched for periods favorable for the floating of bond issues and the letting of building contracts. Between January, 1928, and November, 1931, these were published periodically in the *American School Board Journal.*

Financial Ability of Community

N. L. Engelhardt (26: 89-110) developed a method of measuring ability to pay which involved comparisons among similar cities of the following elements:

> . . . The actual per capita wealth, per capita net debt, tax rate per $1,000 of actual valuation, actual wealth per child in average daily attendance, the cost of maintenance of the schools on various bases, the expenditures for school outlays over a period of years, and the proportion of municipal expenditures devoted to educational purposes.

If a city is favorably located with respect to the central tendency of a significant proportion of these measures, it is assumed to be able to finance a program satisfactorily. Many surveyors have followed this technic with but slight modifications. Among these are Strayer and N. L. Engelhardt (79:179-204) in the Utica Survey and in numerous others; Morrison (51: 27-36) in the Ilion Survey; Hart and Peterson (33: 55-57) in the San Rafael Survey; Pittenger (63) in the Laredo Survey; Barrows (2: 62-65) in the Warwick Survey; Carpenter (8: 65-71) in the Jefferson City Survey; Holy (42: 55-64) in the Springfield, Ohio, Survey; Hull and Ford (43: 35-43) in the Monrovia Survey, to mention only a few typical surveys conducted by different groups in many parts of the country. A slight modification appears in the Holyoke Survey (77:181-89), where the cities are ranked from low to high in each factor and a profile drawn for the city being studied, showing by this means its position in each factor relative to the other cities with which it is compared.

Appraising this method Engelhardt and Engelhardt said (25: 28):

> For the general public to know how their educational cost burden compares with other similar cities as they recognize them, the comparison method has no equal. The limitations in such comparisons must, however, be recognized.

Holy (38) in a study of teachers' salaries in Cleveland used two other indices of financial ability—ability as indicated by manufacture and retail sales.

Current Costs of Education Must Be Considered

Rainey (64: 56) suggested four elements of capital costs which should be taken into account in perfecting a financial policy, *viz.*, annual accrual

cost of plant and equipment extensions; annual depreciation cost of plant and equipment; the interest cost of capital tied up in plant and equipment; and the ground rent of sites occupied for school purposes. Strayer and Haig (73:116-17) developed a measure of cost for the public-school system in terms of "money's worth used up" rather than mere cash disbursements. The elements entering are current expenses plus interest (including imputed interest) plus plant depreciation.

Methods of Payment

Engelhardt and Engelhardt gave (25: 453) three methods of financing school building programs: pay-as-you-go, reserve fund built up, and bonds, both long term and serial.

Essex (28: 35) proposed the following principle relative to bonding vs. cash payments:

> . . . In communities where the minimum frequency of building prevails the proposed policy [which is to pay for each building before the next one is erected] permits a bond term equal to the life of the building; as the frequency of building increases the proposed policy provides for a corresponding shortening of the bond term; and, finally, as building becomes annually recurrent, or nearly so, the policy evolves into the pay-as-you-go plan.

This policy applies separately to each type of building. He (28: 61) pointed out, however, that the policy for financing capital outlays should be flexible and insisted that each city must be treated as a separate and distinct problem. Clark (11:59) held that if the rate of interest on money in a community is lower than the index of school bond prices in the same community, it is questionable if bonds should be issued. He felt, other things being equal, that the community should pay as it goes; for if a community must pay more for its loan than its own money is worth, then it should use its own money.

With respect to the establishment of building reserve funds to meet future plant needs, Ketler (44:26-27) raised three objections: the difficulty of management of public funds; the making of the board the sole arbiter of school plant needs rather than the voters; and the lack of flexibility to meet emergencies. Assuming the same rate of interest, he showed (44:29-31) a substantial differential in favor of borrowing. With respect to types of bonds, serial bonds are favored by the majority of writers, and required by law for school buildings in several states.

CHAPTER II

The School Site

THE preceding chapter has dealt with the survey preliminary to the selection of a specific school site for the purpose of locating a school building thereon. The purpose of this section is to outline the researches bearing on the activities involved in the selection of a site after its approximate location has been determined, and its subsequent treatment.

Factors in Site Selection

Moehlman (49: 141) listed ten factors involved in the selection of a site: location, size, expansibility, hazards, disturbances, drawing power, form, building area, playground area, and landscaping.

To determine the location of a site Womrath (92:18) suggested that the adopted standard maximum enrolment for each type of school be divided by the population index. The quotient will be the number of units of area required to fill each building of each type. The sites for each type should be located as near as possible to the centers of the respective areas they are to serve, not exceeding, however, the maximum walking distance adopted. If the population density is so great that buildings must be spaced closer, then they should be spaced equi-distant. To aid in site selection, Moehlman (104) mentioned maps showing development of industry, commerce, and transportation; social and recreational facilities; civic and non-civic projects planned for the future; contour maps; and aerial photographs. Engelhardt and Engelhardt suggested the use of circles and squares (25: 157). By means of these data and instruments, sites may be selected with reference to maximum size of school devised, maximum walking distance, and various industrial, commercial, civic, and ethical enterprises, as well as topography. Other factors which are pertinent are zoning (25:18) and traffic flow and pupil flow, which should parallel each other (25: 117). They (25: 119-20) pointed out that the preponderance of traffic accidents involve children under nine years of age. The most dangerous time of day is from five to six in the evening and the second is the noon hour.

Standards for School Sites

Standards for sites for the several types of buildings were developed in connection with school building standards by the National Education Association Committee on Schoolhouse Planning (13: 13), by Dresslar (17: 1-5), by Donovan (16: 4-6), by Strayer and N. L. Engelhardt (87: 9-10; 88: 9-14; 27: 15-33; 90), by Holy and Arnold (40), and by the Commission on the Reorganization of Secondary Education (53: 8-10).

Score cards have been developed for appraising sites proposed for school buildings. They resemble generally the school building score cards in having allocated the maximum possible among many subheads on the basis of composite expert judgment. N. L. Engelhardt (98; see also 25: 106) devised such an instrument which allocates 1,000 points among four major factors, *viz.*, location and accessibility, 250; size, 300; topography, 250; utilization and cost, 200. Reeder (110: 178-79) described one developed by L. W. Reese, who classified the major factors as accessibility, surroundings, soil, and general, the latter including satisfaction of patrons, cost, contour for buildings and grounds, sunlight, size, shape or form, and esthetics. Reese (111) published a score card similar to this for selecting school sites for rural consolidated school buildings. The Connecticut State Board of Education (95: 14) published a score card of 100 points allocated as follows: geographical location in relation to school population, 20; size, shape, and contour, 35; environment, 15; services, 25; cost, 5. The California State Department of Education (94: 20) developed a 500 point score card subdivided into fourteen major divisions. Provision was made for drawing a profile of each site by plotting points on horizontal graphs which correspond to the major divisions, thus giving a graphical representation of the appraisal of the site. Engelhardt and Featherstone (97) developed a score card to assist boards of education in the appraisal of sites already purchased or under consideration, which considers location and accessibility, size, topography, utilization, and cost.

Size of Site

The general tendency during the past century has been toward small sites. In 1921 the median size of sites in 429 cities of eight thousand population or more was 34 square feet per child and the 75th percentile was 78 square feet (52: 23). In more recent years the tendency has been toward larger sites. Wood (115) stated that from 1826 to 1918 but 48 sites of more than five acres were selected in New York State, while between 1919 and 1926, 206 more in excess of that size were acquired, with the number increasing year by year. An inquiry by the National Conference on City Planning (99) stated that 60 out of 270 cities replying reported a policy of securing five acres, or more, for elementary-school sites, and ten acres, or more, for high-school. The smaller cities made the best showing. The Educational Research Service of the National Education Association (106) reported 95 cities that purchased a total of 330 sites having a median area of approximately four acres, but there was little relation between size of site and the number of pupils to be accommodated.

The social trend resulting in larger school sites to be utilized in an educational program was explained by Nash (105:20-23), who stated that the unorganized beginning was made in 1886. This was followed by the charity era which was characteristic only of the East. This in turn was

followed by the park era, 1900-10. The succeeding decade brought the playground and recreation commission era which held that recreation was the function of a special group. The period since 1920 is the school era, for the school is the only institution which can reach all of the children.

Among the standards cited above, there is very general agreement on a minimum of five acres for a city elementary-school site and ten acres, or more, for a high-school site; this includes space occupied by the building, lawns, drives, landscaping, and walks. Ready (109: 15-17) computed the units of area or equipment necessary by determining (1) the standard equipment and facilities and (2) the number of pupils to be accommodated. She concluded that the areas shown in Table 1 are necessary, not inclusive of the space occupied by the building and its surroundings. These data mean that an adequate program can be carried out in the small school with a site, the area of which is under the generally accepted minimum; but for this same program in a school of one thousand the site must be larger than the minimum unless the building and its surroundings are considerably cramped.

TABLE 1.—AREAS NEEDED FOR SCHOOL SITES EXCLUSIVE OF SPACE OCCUPIED BY BUILDINGS—ADAPTED FROM READY (107)

Number of pupils	Space needed in acres exclusive of buildings	
	For elementary schools	For junior high schools
100–200	.97	...
200–300	1.01	...
300–400	1.26	...
400–500	2.01	...
500–600	2.17	...
600–700	2.36	...
700–800	2.55	...
800–900	2.70	...
900–1000	3.45	...
Fewer than 500	....	2.7
501–750	....	3.0
751–1000	....	4.7
1001–1250	....	5.4

To accommodate all the pupils simultaneously would require approximately double the space here suggested. Likewise, were additional activities to be included, more space would be required. These studies have the advantage at least of arriving at minimum areas through a process of analysis rather than empirically. This writer (109: 4-9) also summarized statutory enactments as well as state regulations and recommendations in effect in

the various states. Dudley (19: 20-21) computed the minimum rectangular areas required for elementary and junior high schools, inclusive of buildings and surroundings as shown in Table 2. His program of play and physical education differs, however, from Ready's.

TABLE 2.—AREAS NEEDED FOR SCHOOL SITES INCLUSIVE OF SPACE OCCUPIED BY BUILDINGS—ADAPTED FROM DUDLEY (20)

Number of pupils	Space needed in acres inclusive of buildings	
	For elementary schools	For junior high schools
400	2.0	3.5
600	2.75	4.25
800	3.5	5.0
1000	4.0	6.0
1200	4.75	6.75
1600	....	8.5
2000	....	10.25
2400	....	12.0

Acquisition and Cost

Reeder (110: 180-81) listed three methods of acquiring sites: direct purchase, purchase through a third party, and exercise of the right of eminent domain. Engelhardt and Engelhardt (25: 543-48) summarized the laws of the various states relative to acquiring title to a site through the exercise of the right of eminent domain.

Engelhardt and Engelhardt (25:439-47) pointed out that there is no exact or scientific method of determining land values. They listed the Hoffman-Neill rule for measuring the comparative value of inside lots; the Lindsay-Bernard rule and the Somers rule, with applications. They (25: 447) warned, however, that:

> Only by careful working, careful evaluation, and thoughtful judgment will useful and reliable results be obtained.

Sites are not purchased until the time they are required for building purposes in 55 percent of the cities, according to a report of the Better Schools League (93: 2; see also 25: 433). Engelhardt, Hegel, and Womrath (23: 15-19) showed a loss of $185,281 on three school sites purchased before any study was made. The loss was due to additional purchases made necessary as a result of the study. They estimated a saving of $1,420,000 on sites purchased as a result of a careful study in an early state of development. Moehlman (49: 179) cited a study in Milwaukee which revealed that the ratio of the cost of a site in the built-up section of the city to one three miles

beyond the city limits was 375:1; to one two miles out, 200:1; to one one mile out, 100:1; to one in adjoining villages, 60:1; and to one adjoining the city, 43:1. Holy (102:38) found that in St. Louis the average cost of school sites for the period 1904-24 in developed territory was approximately $21,000 per acre, while in undeveloped territory the cost per acre was less than $6,000. The Better Schools League (93: 2) showed that on an average 12 percent of the bond issue is spent for the site, while Engelhardt and Engelhardt (25: 434) reported a New Jersey study in which the range for twenty sites was 3.2 percent to 28.7 percent of the cost of the building.

It is often argued that school sites appreciate in value. Strayer and Haig's study (73: 88-90) of the appreciation in value of all school sites in New York City showed an increase in value of only 4.5 percent.

Utilization of Site

In the use of the school site, allocated games must be so planned that ample space is allowed for each activity with a minimum of interference and no waste of space. Williams (114: 312-18) gave measurement and diagrams of fields and courts used in physical education activities. Hutchinson (103) listed the dimensions of various fields and courts ordinarily found on school playgrounds and gave the diagram of a five-acre field with provisions for running track, baseball, football, field hockey, soccer, tennis, basketball, volleyball, circle dodge ball, playground ball, jumping pit, hurdles, and general equipment. Engelhardt and Engelhardt (25: 145) reported the standards of William A. Stecher. The Playground and Recreation Association of America (107) has prepared an authoritative handbook on the design and equipment of play areas. Curtis (96) has prepared a comprehensive manual concerning equipment lists and directions for leveling, seeding, surfacing, and maintaining the ground.

Hadden (100: 529) reproduced diagrams of fields for both college and high schools so laid out as to economize space and yet provide amply for athletics. Hadden (101: 138-41) also presented a map of the United States on the basis of which football and baseball fields may be so oriented with respect to the rays of the sun in different parts of the country that there is a minimum of interference from that source. He treated baseball similarly, but contended that other games, because of their nature, suffer less interference from the sun's glare.

Landscaping

Engelhardt and Engelhardt (25: 213) urged that plans for landscaping be given consideration from the outset by engaging a landscape architect who will carry his plans forward in cooperation with the school building architect. Womrath (92:230-35) offered a similar suggestion and made recommendations for proper landscaping.

Engelhardt and Engelhardt (25: 223-227), Porter (108), Reeves and Ganders (112: 340-347), and Underhill (113) listed trees and shrubs suitable for landscaping together with suggestions for their care.

Underhill (113) made a study of the cost of grading and landscaping school sites. For eleven schools in the city of Detroit the cost of landscaping ranged from .4 percent to 2 percent of contract for the building; in Columbus, Ohio, from .1 percent to .3 percent of the building contracts; for rural schools from .08 percent to .33 percent of the contract. There was no relation between size of site and cost of landscaping and grading.

The same author (113) also prepared a score card and standards of school beautification. Its major divisions are school location, area, walks and drives, trees, gardens and lawns, shrubbery, barriers (against trespassers), landscape plan, surfacing, environment, and flag pole. The maximum possible score is 1,000 points.

CHAPTER III

School Buildings

IT IS OFTEN asked why our present school buildings cost so much more than they used to. Of course, one large item is the increased cost of labor and materials, though this is a matter which is correcting itself in a measure, due to the business depression. There are many other items, however, that have increased the expense of the present-day building over the school of generations ago, due to the fact that there is an insistent demand for better housing conditions and also more complete educational facilities than those with which we were satisfied in years past. Today there is a demand for the use of some quiet floor material in order to eliminate noise. There is a demand for more elaborate electrical equipment and lighting throughout the building, the installation of radio receiving systems and for moving pictures with sound equipment. Larger auditoriums are installed, together with large gymnasiums with space for many spectators, and swimming pools with their adjoining shower and locker rooms, more miscellaneous rooms for administration and health work, lunch room and kitchen, and rooms for extra-curricular activities. . . . There is a trend toward the reduction in amount of blackboard space provided in the classrooms and a corresponding increase in the amount of corkboards provided. . . . Classroom instruction is becoming more informal, movable furniture is being used, and much more storage space is being made available in each classroom. This storage space takes the form of cupboards, drawers, etc., set flush with the walls, where possible. . . . In many classrooms a sink or wash basin is also provided. There is also a tendency to increase the area of the classroom slightly. (123)

The above statement of recent trends in school building design by a prominent school architect furnishes an introduction to the researches in this field. The fact that the construction of school buildings represents one of the chief items of expenditure in the vast program of public education, totaling $370,877,969 for capital outlay out of a total expenditure of $2,316,790,384 for public-school education in 1928 (238: 28), would lead one to expect that this would be a field of intensive research. It is surprising, therefore, to find that such is not the case. A careful examination of many hundreds of publications on various phases of schoolhouse planning and construction yields a relatively small number of studies which could be classified properly as research.

The increase in the cost of school buildings over that of two or more decades ago is a result of many factors, a number of which have been cited above. An additional important cause of the increased cost is the present insistence on fire resistive construction. The terrible tragedy which took place in Collinwood, Ohio, in 1908, in which 168 lives were lost, had a tremendous effect in emphasizing the importance of erecting school buildings as nearly fireproof as possible. As an illustration, Ohio adopted a most rigid code for the construction of school buildings. Laws have also been enacted in many states which necessitate the use of mechanical systems

of ventilation. All such regulations and improvements have greatly increased the cost of school buildings. The rise in cost is strikingly shown by Davis (141) who found that the value of school plants in Ohio, adjusted to the 1914 building dollar and allowing depreciation of 2 percent annually, increased from $50 per pupil in 1899-1900 to $131 per pupil in 1929-30 and from $1,440 per teaching position in 1899-1900 to $4,200 in 1929-30. In calculating the per pupil value he weighted the number of high-school pupils as two times the number of elementary-school pupils.

Historical

That there has been remarkable development in the design of school buildings is apparent even to a casual observer. From the early work of Barnard (119) until the present there has been an interesting evolution in the American school building. Ayres (118) described this development from 1816 up to the time of the World War. Kintzing (178) and Foltz (154) also reviewed the changes which have taken place during the past century, while Ittner (176) reviewed the developments during the first quarter of the twentieth century and noted the following accepted changes which will continue to influence and advance the science and art of school architecture:

1. The development of plan efficiency due to the evolution of the "open plan" and to expansion and improvement in educational thought and practice.
2. Significant improvements in such matters as safety, lighting, heating, and ventilation of schools.
3. Increasing emphasis on the beautification of exteriors and interiors.
4. The scientific study and application of the principles of sane, sound, and lasting economy.

School Surveys

One of the most practical contributions of research to the solution of problems connected with the planning of school building programs has been the school survey. This contribution was well described by Engelhardt and Engelhardt (147: vi-vii):

> School executives confronted with the problem of wisely expending . . . millions of dollars annually [for school buildings] have resorted to research and survey for evidence and assistance. The educational research agencies of the nation furnish the principles, technics, and the standards with which the ever-growing responsibilities arising out of new plant needs might be met. . . . Out of these studies and the survey of many school systems, guiding principles have been developed, preferred practices have been indicated, and acceptable procedures have been presented . . . for the organization, the administration, and the financing of school building programs.

The use of the school building survey has become so general and the number of such surveys so great that it is considered unnecessary to give citations to them. However, the study of Caswell (130) should be mentioned as it is probably the most comprehensive review of the development and

influence of the survey movement.[1] A recent bibliography of school surveys has been prepared by Smith and O'Dell (214).

Legal and Financial Questions

A number of studies have been made of the numerous legal and financial problems which confront any public-school board which undertakes a building program. Henzlik (167) studied the rights and liabilities of public-school boards under capital outlay contracts. He reviewed the many legal questions which may arise in securing new additions to the school plant, in the form of sites, buildings, necessary appendages, and equipment. J. Smith (215) in a study of the legal limitations on bonds and taxation for public-school buildings found that forty-seven states have limitations of the amount of school bonds which may be issued, ranging from 2 percent to 20 percent of the assessed valuation of all taxable property. He (215: 76-77) also found (1) that most states require a popular vote to authorize a bond issue, (2) that serial bonds are preferable to sinking fund or straight term bonds, (3) that most states limit the maximum number of years for which bonds may be issued, (4) that the maximum interest rate varies from 5 percent to 8 percent, and (5) that thirty-five states require that no school bonds be sold below par. Essex (151) studied the much debated question as to the relative merits of the bonding versus the "pay-as-you-go" plans and concluded that each is fair and just under certain conditions. He recommended the combined use of the two methods, noting the long time trends and the value of the dollar; but suggested that with a carefully planned long term budgeted program of all municipal improvements, the "pay-as-you-go" plan may be used in full or in part with little or no increase in taxation. A comprehensive study of school bonds was made by Fowlkes (156) who classified the types of bonds, analyzed the trends in bonded debts, and studied the problems connected with marketing and retiring bonds. Del Manzo (142) made a similar study in which he outlined a proposed plan for building a bonding program. Other contributions have been made by Halsey (163) and Clark (133).

Closely related to the problems of financing the school building program are those concerned with the selection of the architect and the acceptance of working drawings and specifications. Bruce (125) found by means of a questionnaire sent to cities of 100,000 population and above, that the competitive system of selecting the architect has been largely abandoned; the tendency is to employ an architect of standing and experience either by the job or by the year. The prevailing cost of this service was found to range between 5 percent and 6 percent of the construction costs.

Proctor (198) made a study of 110 sets of working drawings of school buildings erected in Missouri. He determined that a complete set of working drawings should contain a plot plan, floor plans, elevations of all ex-

[1] See Chapter I.

teriors, section plans, framing plans for steel and concrete construction, large scale detail drawings, electrical installation plans, and plumbing, heating, and ventilating plans. Byrne (129) recently worked out a very complete checklist for materials for public-school building specifications.

Schoolhouse Planning

Numerous studies have been made of the allotment of space in school buildings of various types. Terry (233) made an investigation of 149 junior high-school buildings with enrolments ranging from 200 to 1,750. He listed the accommodations provided in these buildings with percentages of the total number of buildings providing each type of room. An interesting observation resulting from this study was that buildings especially designed as junior high schools were in all cases more completely adequate for the junior high-school program than were remodeled buildings. Bentley (121) made a similar investigation of junior high-school buildings. He found that the buildings which are gaining favor are not so elaborate as are the senior high-school buildings, that science laboratories are large rooms with relatively simple equipment, that there is a tendency toward the general shop, that there is a tendency to place the lunch room in connection with the household arts department, that ample provisions are being made for the library, that from 50 to 65 percent of the capacity of the buildings is given over to special rooms, and that most of the buildings are planned so that many of the special features are accessible to the public without interfering with other parts of the plant. Pittenger (197) analyzed thirty-nine floor plans of new junior high-school buildings that appeared in the *American School Board Journal* from 1921 to 1925. Gump (162) made a similar study of space provisions in junior high-school buildings in Ohio. Spohn (219) collected data for three periods centering around the years 1907, 1917, and 1927, showing changes and trends in space provisions for high-school buildings over a period of twenty years. The building plans for twenty-four schools erected in each period were studied. Of the 376 kinds of space provisions, only 20 kinds were found in more than 50 percent of the plans. Koos (179, 180) and Younger (243) reported similar studies. In an analysis of 290 elevations and floor plans for new school buildings, Pittenger (196: 150) reached the following conclusions:

1. The number of rooms per floor seems to be a decisive factor in determining whether or not a building shall be of the open or closed type.
2. Roof type is mainly determined by the number of floors.
3. Basements are most likely to be found in two- and three-story buildings, and most frequently accompanying flat roofs and plans of the closed type.
4. Of open-type buildings, the T and L forms are preferred for those with relatively few rooms per floor, and the U, E, and H forms for larger buildings.

Shambaugh (211) studied the space provisions in fifty-eight high schools to discover how school planning reveals the trend of the curriculum. He

found that the phases of teaching receiving increased attention in new buildings are those that offer training in vocations, health, and social developments. N. L. Engelhardt (150) made a state-wide analysis of new school building construction to discover the outstanding faults, but concluded that there was no tendency to err in any one particular field. Turner (237) found that school administrators believe the size of high schools ought to be limited to 1,200 to 1,500 students. A study of the trend in gymnasium construction was made by Winters (242). Hansen (165) investigated the provision made for teacher unit offices, rest-room suites, and large rest rooms in high-school buildings.

One of the most complete studies on the subject of schoolhouse planning is the work of the Committee on School House Planning of the National Education Association (139). The report of this committee contains the results of a study of the areas allotted to various purposes in a large number of schools. The committee prepared a "Candle of Ratios" in which they recommend the divisions into which the total floor area of a school building should be divided. These are:

Instruction, not less than 50 percent.
Stairs and corridors, not over 20 percent.
Administration, not over 16 percent.
Walls and partitions, not over 10 percent.
Flues, not over 3 percent.
Accessories, not over 1 percent.

Among the many topics covered by this report is a technic for estimating the cubical cost of school buildings and also a description of several methods of determining the schedule of rooms. The National Council on Schoolhouse Construction (190), through its committee on standards, prepared a number of suggestions in regard to elementary classrooms, corridors, stairways, and exits.

The importance of an adequate determination of the facilities needed in a new building cannot be overestimated. Many of the defects too frequently found in new school buildings could have been easily avoided if a carefully determined statement of the needs had been furnished the architect. A formula for determining the required number of rooms for high schools has been prepared by Packer (195). The following formula gives the exact number of rooms needed when class sections are evenly distributed throughout the periods of the day:

$$\frac{\left(\begin{matrix}\text{Registered no. of}\\ \text{students in subject}\end{matrix}\right) \times \left(\begin{matrix}\text{Average no. of}\\ \text{periods daily}\end{matrix}\right)}{(\text{Average size of class}) \times (\text{No. of periods in school day})} = \text{No. of rooms}$$

To allow for loss incident to program making it is necessary to add corrections to the direct result of not more than 5 percent in schools enrol-

ing over 1,000, 8.8 percent for those enroling 500 to 1,000, and 14.7 percent in schools of 150 to 500. Anderson (116) developed a similar formula to be used in determining the housing requirements of junior high-school programs, which is as follows:

$$\text{No. of rooms} = \frac{\text{(Pupil periods per week in subject)}}{\text{(Average class)} \times \text{(No. of periods per week)} \times (1 - S)^{1}}$$

School Building Utilization

A similar formula, but intended to measure the utilization of an existing building, was prepared by Morphet (187). By this method it is possible to determine both room utilization and pupil station utilization. In a study of fifty-eight secondary schools, all considered to be overcrowded, in which he used this formula, Morphet found that the average room utilization during class periods was only 75.4 percent and pupil station utilization only 41.7 percent. He concluded that the probable maximum percentage of pupil station utilization will be much less than 100 percent for each type of room and will seldom exceed 70 percent for the entire building. Morphet's technic has been used in a number of studies of school building utilization. Chandler and Guthridge (132) made a survey of building utilization in high schools located in twelve cities of Kansas and concluded that there is great variability in the length of the school week, length of class periods, and percentage of utilization of the rooms in a building. They found that auditoriums are the least used and that laboratories are most frequently overcrowded. Edwards (146) found in a study of the utilization of the instructional rooms of the first four grades of the elementary schools of three cities that when 15 square feet were used as the amount of classroom floor area to be provided per pupil, the average school was using 70 percent of the classroom floor space.

Hamon (164) collected data on 1,393 instruction rooms in twenty-two colleges located in the Middle West, New England, the South, and the metropolitan area of New York City. The one-hour period and the full college week were used as units of utilization measurement. He found that recitation and lecture rooms were used more during the periods before lunch, and laboratories were used slightly more during the four periods following lunch. Teachers colleges showed a higher utilization than liberal arts colleges, engineering colleges, and state universities. In a study of one high school, Sears (210) evolved a plan whereby any school executive may study the costs of schoolhousing in his system as related to the use made of the buildings. Sears found:

[1] S represents the percent of the total number of classroom periods unoccupied during the week. This unoccupied portion is the allowance in number of classrooms over and above the number which would function at 100 percent with the same program. These allowances (S) are as follows: Small schools, $S = 12$; medium schools, $S = .08$; large schools, $S = .05$.

1. There is very poor adjustment of size of class to size of room.
2. There are many rooms vacant during all hours, and especially during the early and late hours.
3. The area of floor space varies widely.
4. The buildings are entirely vacant 30 percent of the time.
5. On the average only 50 percent of the housing facilities are actually in use.

Shields and Holy (213) in a study of auditorium-gymnasium facilities in 513 Ohio schools found some interesting facts in regard to the median number of hours of use per week as given in Table 3.

TABLE 3.—MEDIAN HOURS OF USE PER WEEK OF AUDITORIUM-GYMNASIUM FACILITIES IN OHIO SCHOOLS UNDER COUNTY SUPERVISION IN 1929-30

Types of auditorium-gymnasiums	Median hours of use per week	
	School use	Community use
Combination, with all seats on floor level	20.4	1.6
Combination, with seats on floor level and balcony	22.5	1.9
Combination, using stage of auditorium as a gymnasium	27.5	3.0
Separate auditorium and gymnasium	27.7	1.8
Auditorium alone	8.5	.6
Gymnasium alone	15.0	.8

School Building Costs

One of the factors of prime importance in the construction of school buildings is cost. A number of variables, such as the administration of the building program, standards of construction, prices of materials and labor, combine to determine the cost of school buildings. No single unit for determining the relative costs of buildings has been universally accepted, but the cubic foot is probably the most common. The cost per room, per pupil accommodated, or per square foot are sometimes used. Milligan (186) compared the various methods of computing building costs and illustrated the most accurate methods.

The fluctuation in school building costs, including both material and labor, was shown by Clark and Buros (134) in the form of index numbers covering the period from 1920 to 1929. Burgess (126) found that the rise in building costs was very gradual from 1841 to 1915, with the exception of the period during the Civil War. The rise from 1915 to 1920 was very rapid and the cost for the same educational service in 1920 was more than twice as much as in 1915. Holy and Arnold (171) studied the relation between school building expenditures and building costs. They found that in Ohio from 1915 to 1930, as the index of construction costs increased,

the amount of school building construction also increased, and as costs decreased there was likewise a decrease in the amount of building done. Hull (174) investigated the administration of school building programs in 103 cities of 30,000 population or over in thirty-three states, including 1,082 school buildings. Among his conclusions are (1) economies in building expenditures are more readily realized by the adequate control of those elements of planning and management that determine building costs than by curtailing overhead expenditures for administration; and (2) expenditures for expert educational or engineering services are insignificant from the standpoint of cost, in comparison with the variations in construction costs due to inefficient and unscientific planning. An earlier investigation by Burgess (127) under the auspices of the Russell Sage Foundation constitutes one of the most complete studies of school costs up to that time. The part of the investigation dealing with building costs furnishes among others, the following conclusions:

1. Since 1890 building costs have absorbed from 16 to 19 percent of all school expenditures.
2. Rising standards of building were for many years offset by low costs of building.
3. For 75 years, 1841 to 1915, the cost of building increased about 84 percent, or about 1 percent a year.
4. From 1913 to 1919 the cost of city school buildings has risen about 150 percent, or 25 percent a year. . . .
5. In the past few years rising standards of construction have gone with rapidly increasing building costs.

In a study of school building costs in Iowa, Lindsay (182) based his analysis on the pupil unit, using the capacity estimate of the building, and also on the cubic foot unit. His investigation included 128 brick school buildings erected in Iowa from 1910 to 1921. The larger part of these buildings were of the combination type, housing both elementary and high school. He found the costs of construction were lowest in 1912 when the average was $99.14 per pupil and 15.7 cents per cubic foot. The highest point was in 1920 when the per pupil cost was $352.44 and the cubic foot cost was 49.8 cents.

New Jersey (192) conducted a survey of building costs beginning in 1921. During the years 1924, 1925, and 1926 the median cost for high-school buildings in the state was found to be $508 per pupil and $12.14 per square foot. The median cost for new elementary-school buildings was $330.58 per pupil and $11.30 per square foot. The median number of square feet per pupil for high schools was 43 and for elementary schools 32. Holy (169) gave data showing the per pupil cost of replacing the housing provided in Cleveland between 1920 and 1921, based on the January, 1932, index of building costs as follows:

Per pupil cost grades 1-6 (includes kindergarten and special classes)	$380
Per pupil cost junior and senior high school	568

Table 4 summarizes data on building costs published by the Better Schools League (124).

TABLE 4.—NUMBER OF SCHOOL BUILDINGS IN THE UNITED STATES CONSTRUCTED DURING THE PERIOD 1920-26 AT VARIOUS CUBIC FOOT COSTS

Year constructed	Type of school	Number of buildings with cubic foot costs in cents							
		20 to 25	25 to 30	30 to 35	35 to 40	40 to 45	45 to 50	50 and more	Total
1920–21	Elementary schools	4	1	1	2	1	..	1	10
	Junior and senior high schools	8	10	10	8	2	..	3	41
1922–23	Elementary schools	3	4	3	3	0	0	0	13
	Junior and senior high schools	7	13	6	4	3	3	1	37
1924–25	Elementary schools	1	6	2	4	1	1	1	16
	Junior and senior high schools	6	6	4	6	4	0	1	27
	Total	29	40	26	27	11	4	7	144

Figures prepared by Ittner (175), showing the cost of school buildings per cubic foot in the Middle West from 1900 to 1924, reveal that the highest point was reached in 1920 with an average of 40 cents per cubic foot. The increase in costs was gradual from 1900 up to 1916 when the average was 19 cents per cubic foot. The increase from 1916 to 1920 was very rapid but was followed by a sudden drop until 1924 when there was another upward trend.

Spain (218) made a study of the sixteen-room and the twenty-four-room units, the standard elementary-school building units in Detroit, to determine the relative efficiency in the use of the building of the platoon and old type of organization. He found that in the sixteen-room unit it cost $8 per pupil to provide auditorium and gymnasium for the platoon system over and above what it would cost to build extra classrooms to house the additional number of pupils possible to accomodate under the platoon plan. In the twenty-four classroom unit buildings, by building an auditorium and gymnasium, 480 additional pupils can be accommodated. The cost of the auditorium and gymnasium was $24 per pupil less than the cost of the extra classrooms necessary to care for the 480 pupils under the old plan.

Operation and Maintenance

Holy and Davis (170) made a study of methods of determining expenditures required to maintain the *status quo* of school plants. They found that the average age of school buildings recommended for replacement in ten

city surveys was 47.6 years, while the average age of buildings actually replaced in one large city was 43.2 years. They gave a method for determining the expenditure needed to offset depreciation of a school plant and expansion in school enrolment, in terms of the present valuation of the dollar based upon index numbers of construction costs. Murray (188) also formulated a technic for the computation of the depreciation allowance, together with a score card for estimating the useful economic life of school buildings.

Davis (140) studied the school plant operation costs over a period of twenty years from 1904-05 to 1924-25 of thirty elementary schools located in St. Louis. No additions to or remodeling of any of the buildings was done during the twenty-year period. A comparison was made of the index of cost of living and the cost of school plant operation, in which it was found that the index of plant operation was above the index of living costs in 1905, below in 1920-21, and slightly above again in 1924-25. Similarly, the plant operation dollar was worth $1.23 in 1904-05 compared to $1.32 for the general dollar, while in 1920-21 it was worth $.62 as compared to $.50 for the cost of living dollar. In 1924-25 the plant operation dollar was worth $.57 as compared with the $.59 for the cost of living dollar. The index of living costs was falling from 1920 to 1924, while the index of school plant operation continued to rise.

Gosling (159) investigated the percentage distribution of the various items of maintenance of the school plant for twenty-seven cities of more than 100,000 population for the school year 1925-26. Schwartz (209) made a study to determine the elements of public-school buildings that are most frequently repaired and the relative importance of such repairs. His study also attempted to determine the relationships existing among the six factors: size of building, average yearly cost of repairs for each building, average yearly cost of repairs for each equivalent classroom, age of building, score of building, and type of building.

Garber (157:26-37) made a comprehensive investigation of the functions of the school janitor in 1,097 cities. The study includes the methods used in sweeping floors, the periodic cleaning and treatment of floors, dusting, washing of windows, and the cleaning of toilets. Murray (189) made an experiment to find the effects of instruction and supervision upon janitorial service. By means of a score card he determined that (1) an improvement was made in each item except one and that ranked high at the first scoring; (2) the improvement was uniform in practically every item; (3) the janitorial service improved when the janitors were instructed in their duties and supervised in their work.

Reeves and Ganders (201) prepared a useful book on school building management which covers many of the problems of operation and maintenance.

Heating and Ventilation

V. Smith (216) reviewed the history of the development of opinion on the much debated question of school ventilation. It was formerly believed that the most important function of ventilation was the dilution of the carbon-dioxide content of the air. Later, it was believed that fresh air was needed to lessen the danger from poisonous organic effluvia found in air that had been breathed. An excellent account of the evolution of the science of ventilation is found in an article by West (239) in which he reviewed the recent major investigations and gave the names of the leading students of the subject. Winslow (241) added further historical information, and explained the formula by which the 30 cubic-feet-per-minute idea was originally determined. He also gave information pertaining to the legal requirements of the various states.

Among the important earlier studies is that of Thorndike, Ruger, and McCall (236) reported in 1916. They conducted two experiments with sixth-grade pupils over periods of one semester and three months respectively, to determine the effects of outside air and recirculated air upon the intellectual achievement and improvement of the pupils. In-so-far as was possible by specially constructed classrooms, selected teachers, etc., all factors were made constant except the variation of the air. The results showed very little difference in achievements or improvements, the slight difference being in favor of the group with recirculated air. In 1917, Thorndike and Kruse (235) reported a study of the effect of humidification of the air of a school room upon the intellectual progress of two groups of sixth-grade pupils over a period of approximately four months. The study revealed the fact that the humidification of school rooms during the winter months was not productive of any improvement in mental work.

In February, 1919, a series of tests upon conditions within the classroom dependent upon the type of heating and ventilation were made in the James Burrill Angell School, Detroit, Michigan (220). Sixteen typical classrooms were used in the study—eight had natural ventilation, and eight were heated and ventilated by the regular mechanical forced ventilation provided in the school. The results of the tests were favorable to the forced ventilation. A similar experiment but with opposite results was conducted in Cleveland during February and March, 1928 (138). Two schools equipped with split steam systems, direct radiation, and automatic regulation, and supplying 30 cubic feet of air per minute per pupil; and two similar schools having window air supply, gravity vent flues, and direct radiation but without automatic regulation, were used in the experiment. The results indicated that the schools where mechanical ventilation was used had a higher incidence of respiratory disease than did the schools where natural window ventilation was used.

A study by Westover (240) of air circulation and variations in temperature readings at set stations in the rooms as affected by the plenum system,

split system, and unit system of heating and ventilating, gave results favorable to the unit system.

McLure (185) gave an account of the changing conceptions of ventilation, of state ventilation laws for school buildings, and an analysis of present standards and practices. He concluded that experimental research over several decades has failed to confirm the theory that expired air, in rooms ordinarily occupied, contains poisonous or injurious substances or that it is the cause of the discomfort usually experienced in such rooms. He stated that it has been shown repeatedly that the factors of major importance in ventilation are the physical properties of air, namely, temperature, relative humidity, and movement. On the basis of the evidence found in his investigation, McLure concluded that mechanical ventilation cannot be regarded as essential for school rooms unless they are located in noisy, dusty, or odorous surroundings, or in case of other special conditions.

Scherer (205) reported an experiment in the ventilation of school buildings in Rochester and also described the present system of heating and ventilating adopted in the Rochester schools known as the Danforth System.

The work of the New York Commission on Ventilation (193) probably has attracted more attention and comment than any other. The final report of this Commission, recently published, contains a review of outstanding research done both by the Commission and by other investigators. The final conclusions of the Commission are:

1. The major objective of school room ventilation is the provision of such atmospheric conditions as will facilitate the elimination of heat from the body surface without the production of objectionable drafts. In practice, this means the maintenance of a room temperature of 68° to 70° F. with moderate air movement. Under such conditions special control of humidity is not essential except perhaps in certain northern regions where humidity is exceedingly low in cold weather. A minor objective should be the provision of sufficient air change to avoid unpleasant body odors.

2. The avoidance of overheating is of primary and fundamental importance for the promotion of comfort and efficiency and the maintenance of resistance against disease.

3. Desirable conditions may be obtained by at least three methods of ventilation when proper design and operation is provided: (a) by plenum ventilation, (b) by local unit ventilation, (c) by window-gravity ventilation. For the average school, favorably located, window-gravity ventilation seems to be the method of choice on grounds of comfort and of economy.

4. Further investigations, in regard to the physiological effects of radiation and convection of heat, of vertical variation in temperature, and of electrical and other properties of the atmosphere, are greatly to be desired.

5. The present laws and regulations requiring a supply of 30 cubic feet of air per pupil per minute in the school room have no justification in theory; and, in practice, may involve a serious handicap to progress in the art of school ventilation.

6. Such regulations should be replaced by laws outlining the major objectives of school room ventilation and delegating to some small expert official body the power to determine whether specific plans for school ventilation are adequate to attain those objectives.

Among other investigations worthy of note are those by Greenburg (161), Hines (168), Mahar (184), Gardner (158) and Robinson (202).

Construction

A great deal of research has been done on general problems of construction methods and materials but relatively little on the specific construction problems of school buildings. Most of these problems naturally come within the realm of architecture and engineering. However, the construction problems encountered in the erection of schools are so numerous that they should challenge the careful consideration of those capable of making such studies.

The problem of minimum live loads allowable in the design of buildings was the subject of a nation-wide study conducted by the Building Code Committee of the United States Department of Commerce. The results of this survey, as they pertained to school buildings (153), were that in 86 cities of the 109 studied, an average floor load requirement of 69.9 pounds per square foot is made. Forty-one cities set the minimum load for classrooms at 75 pounds, while the average load permitted for assembly rooms is 99.5, and for corridors 92.5 pounds per square foot.

The United States Bureau of Standards (160) conducted experiments over a period of ten years to determine the effect of fine grinding of cement on the strength of concrete, the effect of moisture on the adhesion of mortar to bricks, and the physical properties of terra cotta as a building material. From the results of these tests the following conclusions were drawn:

1. No retrogression is shown in the compressive strength of the concretes at the end of the ten-year period.
2. In general the fineness of the cement increased the strength of the concrete.
3. All cements do not give the same increase in strength with the same increase in fineness.
4. The effect of fineness of cement on the strength of concrete diminishes with age.
5. The 1:2:4 mixes show better increases of strength with the same increase in fineness than do the 1:3:6 mixes.
6. The strength of the bond between cement mortar and bricks is greater when the bricks are wet rather than dry and when the mortar itself is quite wet.
7. The tensile strength of architectural terra cotta as compared with building stone of like absorption was found to be high.
8. Terra cotta must meet certain requirements in climates having freezing weather.
9. Keeping water out of terra cotta structures by proper flashing was found to be beneficial, especially where steel which would otherwise rust is used in the structure.

Challman (131) made a compilation of the laws, standards, and rulings of the state departments of education in several of the states governing the number, width, runs, landings, risers, and treads of stairways and other special restrictions governing corridors and exits. A building exit code has been prepared by the National Fire Protection Association (191), which gives requirements for construction of doors, stairways, and corridors, and also a formula for determining the number of required exits.

Acoustical treatment of various rooms in school buildings has become increasingly common in recent years. Developments in the art of sound absorption have made such treatment practical in schools. In the early days of acoustical experimentation, numerous methods were tried. Clark (135) described the use of wires in the chamber of the House of Representatives in the new parliament building in Wellington, New Zealand, in which it was found that the stretching of wires, no matter how arranged, had little or no effect upon the acoustics. Bagenal (137), an English architect, conducted an experiment to determine the effect of the use of Cabot's quilt upon the ceiling of classrooms to reduce reverberation. The experiment showed that one layer reduced reverberation from 50 to 80 percent depending upon the pitch of the sound; the reverberation of the lower tones was reduced most. Heyl (117), senior physicist in charge of the sound laboratories of the United States Bureau of Standards, made a study of the acoustical difficulties of auditoriums. He limited these difficulties to three—echo, reverberation, and dead spots, and gave the causes and methods of elimination for each. He decided that shape, size, and interior finish are important factors in establishing desirable acoustical properties. Sabine (203) studied the transmission and absorption of sound by a wood stud partition with varying types of lath and plaster. Metal and wood lath and gypsum and lime plasters were used in different combinations and ages.

Lighting and Orientation

Clark and Beal (136) reported a comprehensive study of the natural illumination in four selected classrooms in a modern school building conforming rather closely to existing standards for daylight illumination, over a period of nine months in which approximately 45,000 observations were made. The study revealed that the daylight illumination of the pupils' desks varied greatly, and that practically all of the desks are inadequately illuminated at times. The report of the National Education Association Committee on School House Planning (139:90-121) contained a study by Freeman who concluded that, using five foot-candles as a standard requirement, buildings which were constructed in accordance with the prevailing standards of glass area give deficient illumination in the darker parts of a room, under less favorable conditions of season, weather, and time of day. Another investigation (177) concluded that the amount of window space in itself is of little significance; light should come from above and is best admitted through high windows on two or more sides with shutters to reflect light to the ceiling.

Dates (181) reported a study of the artificial lighting of school rooms conducted in Cleveland. Various types of artificial lighting units were used and recordings of light intensity made at different stations in the rooms. It was recommended that all classrooms be wired for six outlets per room and equipped with direct lighting fixtures and fitted with inclosing

glassware, 16 inches in diameter. Bennett (120) discussed the arrangement of classroom seating in relation to the source of light. He also described several experiments on this subject.

The question of the proper orientation of school buildings has been one upon which opinions have varied. There have been only a few experiments designed to find the most suitable orientation. Dresslar (144:43-44) reported a study by Robert H. Southerland based upon "desk hours" of sunlight interference and found that the best sanitation and least interference from direct sunshine was obtained when the classrooms faced either east or west. In a later experiment (145) a model school room was built in such a way that it could be revolved in any direction and set upon the flat roof of one of the buildings of George Peabody College for Teachers. Data were collected from 8:00 A. M. to 4:00 P. M. one day each week from November to April. Conclusions were that in the latitude of 36° 10′ north, the order of preference of orientation is west, east, southwest, southeast, and south. Shawan (212) wrote a brief description of state laws and rulings of state departments of education regarding the amount of light admitted to school rooms and the direction from which it comes.

Score Cards and Building Measurement

The development of the school survey has brought with it the development of numerous scoring devices intended to give objective measures of the efficiency of the school plant. Such devices have been prepared to score practically every phase of the school building from the plans and specifications (217, 223, 225) to the janitorial engineering service (148). Reese (200) prepared a score card for selecting the site for a consolidated school. There are a number of such cards for village and rural schools, among which are those prepared by Strayer and Engelhardt (230), Stevenson and Ashbaugh (222), Butterworth (128), Dick (143), and various state departments of education (194, 204). Schmidt (208) and Strayer and N. L. Engelhardt (226) have scoring devices for city school buildings. Score cards for elementary buildings were prepared by Stevenson (221) and Strayer and N. L. Engelhardt (227). Score cards for junior high-school buildings have been prepared recently by Holy and Arnold (172) and by Strayer and N. L. Engelhardt (229). The Strayer-Engelhardt Score Card for High School Buildings (228) is well known. Evenden, Strayer, and N. L. Engelhardt (152) published a score card for the physical plant of normal schools and teachers colleges.

Closely allied with the scoring cards are standards covering the various elements entering into the arrangement and construction of the school plant. Among the most widely used of these are the standards for elementary schools and for high schools formulated by Strayer and N. L. Engelhardt (231, 232). Standards for junior high-school buildings have just been published (149). Holy and Arnold (173) recently completed a formula-

tion of standards for junior high-school buildings in which they used the recommendations of many junior high-school principals and teachers and the criticism and suggestions of more than one hundred school architects and school building specialists.

Miscellaneous

There are a number of studies which are worthy of note, but as they deal with a variety of problems concerning school buildings, they cannot be conveniently classified. These studies will be reviewed briefly in this section.

Blackboards—Excessive blackboard space is being installed in the average school according to the conclusions of Hart and Peterson (166), who made a study of the use of blackboards in 784 junior and senior high-school rooms. Forty percent of all the blackboards now installed in junior and senior high schools might be removed without imposing any handicap upon instruction. More effective classroom instruction should be possible through larger use of tacking space and bulletin boards. This investigation classifies rooms according to subjects taught in them and recommends the amount of blackboard space which should normally be adequate.

Schmidt (206) investigated the proper height and width of blackboards. (See Table 5.) The study was carried on through data obtained from sixteen schools and ninety-four rooms, and recorded the writing of 1,449 pupils.

TABLE 5.—RECOMMENDED BLACKBOARD DIMENSIONS, AFTER SCHMIDT (206)

Grades	Height of chalk rail	Width of blackboard
1–3	28″	36″
4–5	32″	36″
6–8	36″	36″

Coatrooms, wardrobes, and lockers—A questionnaire study was made by Loring (183) to determine the relative costs and efficiency of coatrooms, wardrobes, lockers in corridors, and lockers in centralized groups in primary, grammar, and junior and senior high schools. Analysis of returns showed that administrators favored coatrooms adjoining classrooms for primary and grammar schools and the corridor lockers for junior and senior high schools. The architects recommended wardrobes of the Chicago type for primary and grammar schools and the corridor lockers for junior and senior high schools. Opinion was much divided about types of locks and ventilation of lockers.

Medical inspection facilities—Berkowitz (122) prepared a description, with illustrations and floor plans, of the provisions made in several large

cities to make medical inspection of school children. This is followed by practical suggestions and a table of essential requirements for school medical rooms. A blank form for the survey and inspection of medical rooms is given in the appendix.

Sanitary conveniences in schools—As a result of a lack of research on the subject, there has been a marked difference of opinion as to the number and design of the sanitary conveniences to be provided in schools. Schmidt (207) studied this question, and formulated recommendations as to the number and size of toilets and lavatories. A similar study but more comprehensive is that of Thomas (234). This study, including all types of plumbing installations, probably furnishes the only objective data now available on many of these features of a school building.

Cafeterias—Ford (155) made a complete study of the school cafeteria. Among his recommendations are that the upper floor of the building is the best location for the cafeteria; 9 square feet per seating should be provided in the dining room; 2 square feet per dining room seat should be provided for auxiliary rooms. Other recommendations concern lighting, ventilation, and equipment.

Auditorium-gymnasium facilities—There have been a number of plans for providing auditorium and gymnasium facilities, especially for smaller schools where limited funds have made these relatively expensive units a serious problem. Shields and Holy (213) made an inquiry into the types of these facilities provided in 513 Ohio high schools under county supervision. Their findings are shown in Table 6.

TABLE 6.—DISTRIBUTION OF AUDITORIUM-GYMNASIUMS IN OHIO HIGH SCHOOLS UNDER COUNTY SUPERVISION IN 1929-30

Types of auditorium-gymnasiums	Number of schools	Percentage of schools
Combination, with seats all on floor level	148	29
Combination, with seats on floor and balcony	138	27
Combination, using stage of auditorium as a gymnasium	11	2
Separate auditorium and gymnasium	107	21
Auditorium alone	24	5
Gymnasium alone	16	3
Other types, such as rented halls, etc.	25	5
Neither auditorium nor gymnasium	44	8
Total	513	100

CHAPTER IV

Equipment and Apparatus

THIS chapter briefly outlines some of the more important recent developments in the field of school equipment and indicates some noticeable trends established by recent practices.

Importance of Planning

Educational administrators, teachers, and architects have come to realize that equipment planning is important, and that it is a function requiring the cooperation of many specialists. When a new school is to be established, the first consideration should be the pupils to be accommodated, and the next consideration should be the purpose of the school. When these questions have been answered in terms of organization and curricula, the problem may be reduced to the activities of the pupils in school. At this point the *equipment problem* enters the picture, as pupil activity determines the design of equipment (256, 268, 272, 273, 286, 309, 330, 333, 335, 340, 357). If the activity is merely listening, an opera chair satisfies the demand; while if the activity is preparing a meal, the necessary equipment is much more complicated.

Educators must determine the purpose of equipment and prepare the educational specifications. Commercial manufacturing companies are prepared to work out the technical structural details for any piece of equipment for which there is a demand.

When the size and shape of equipment have been determined, the necessary unit of working space calculated, the size and arrangement of the group decided, it is time to consider the size and shape of rooms. Thus, school architects have come to realize that the design of a building as a whole cannot be attempted until all of these interior dimensions have been determined. Equipment planning, therefore, has become an important factor in the general plant program.

Widespread Interest in Equipment

The widespread interest in equipment, both popular and scientific, is manifested by the large volume of literature dealing with this phase of education and the interest shown in the equipment exhibits at the annual meetings of the Department of Superintendence of the National Education Association (314, 315, 316).

Nature of Equipment Literature

Scientific studies based on objective data or carefully controlled experiments are noticeably lacking. The study by Bennett (256) is probably the

most scientific investigation which has been made in school seating. Curtis (268, 269) summarized several experimental studies dealing with the relation of equipment to methods of teaching science. The United States Department of Commerce (347) recently made an important objective study relative to the manufacture of seating equipment. Baldwin (251), Blom (258), Brodshaug (260), and Kemmerer (308) produced scientific studies dealing with certain special aspects of equipment and apparatus. However, by far the larger part of the voluminous literature relating to school equipment and apparatus has been in the realm of opinion. Some of these opinions, although not supported by objective data, have had and will continue to have great influence because of the recognized ability of the authors.

Seating

Probably the most important item of public-school equipment is classroom seating. Many controversies have arisen in the past few years regarding the proper type of classroom seat and desk. New types of seating have been developed, and a great volume of literature consisting of scientific research and opinion has been published (245, 248, 256, 272, 286, 293, 330, 335, 340, 342).

TABLE 7.—TRENDS IN TOTAL SEATING SALES OF ALL MAJOR MANUFACTURERS

(Adapted from United States Department of Commerce Survey of Public Seating Industry)

Type of seating	Percent which each type was of the total of nine types for each year					Significant trends
	1927	1928	1929	1930	1931	
1. Combination stationary	57.5	51.9	44.8	46.7	32.8	Decrease
2. Combination adjustable	4.3	4.4	3.3	1.3	1.1	Decrease
3. Separate desks and seats	12.6	12.5	12.1	7.2	5.9	Decrease
Total stationary	**74.4**	**68.8**	**60.2**	**55.2**	**39.8**	**Decrease**
4. Wood movable	4.6	4.9	5.6	2.2	4.5	.....
5. Steel movable, 4-post type	9.6	12.0	11.7	9.8	9.9	.....
6. Other steel movable	6.7	8.3	11.0	10.7[1]	13.7[1]	Increase
7. Classroom tables and chairs	0.5	0.7	2.6	8.3	15.9	Increase
8. Steel tablet-arm chairs	2.7	3.2	3.3	4.6	4.7[2]	Increase
9. Wood tablet-arm chairs	1.5	2.1	5.6	9.2	11.5	Increase
Total movable	**25.6**	**31.2**	**39.8**	**44.8**	**60.2**	**Increase**

[1]Universal type.
[2]About equally divided between pedestal and four-post type.

The United States Department of Commerce (347), in cooperation with the Trade Practice Committee of the Public Seating Industry, made a comprehensive survey of the public seating industry for the three years 1927, 1928, and 1929. This survey has been continued in unpublished form for 1930 and 1931. It offers the most reliable report of the trends in school seating that has ever been made available, as it includes all of the major manufacturers of public seating. During the four-year period of 1927 to 1930 inclusive, the total annual sales of all major manufacturers was something over one million pupil units of school seating. For the year 1931, the total sales dropped off to slightly more than three-quarters of a million. Table 7, adapted from the data of the United States Department of Commerce, shows the percentage for each type of seating of the total sales for the nine selected types listed for each of the past five years.

This table shows the very significant fact that movable seating has made a material gain over stationary seating during the past five years. In 1927 approximately three out of every four seats sold were stationary, while in 1931 only two seats out of five were stationary. The greatest percentage of loss was in the combination adjustable seats, while the greatest percentage of gain was in classroom tables and chairs. It is probable that many classrooms have been furnished with locally made tables. It is also of interest to note that the greatest annual percentage increase of movable seating was in the year 1931, the year for which the gross sales of all types of seating were the lowest.

Equipment for Physical Sciences and Household Arts

Questionnaires were returned to the author from five of the larger manufacturers of science equipment regarding the market trends in science and household arts equipment during the past three years. There was unanimous judgment on only two items: the trend away from the hollow-square arrangement of food laboratories, and the trend toward two-student tables for general science and biology. Although manufacturers were not in full agreement, there seems to be a trend toward food laboratory stoves built flush with table tops instead of the hot plates mounted on tables. There is also some tendency to arrange food laboratory tables, stoves, and sinks in rows or to combine the row arrangement with unit kitchens. Valuable information relating to household arts equipment may be found in Brodshaug's study (260). In the opinion of the manufacturers of equipment there is some trend toward the use of combination rooms for both science lecture and laboratory.

As revealed by the types of equipment on the market and the literature in the field, there seems to be a decided trend toward multiple-use equipment and rooms. In small high schools all the physical sciences may be taught in one room with the same furniture, and it is also feasible to teach clothing

and foods in a single combination room (301). There is a large volume of literature published in the educational and scientific journals dealing with student-made science apparatus (288, 294, 344). The demand for curtailment of school costs may be responsible for the increase in home-made apparatus and combination equipment. This practice has many educational values as well as financial economies.

There is a school of thought regarding the teaching of science which would minimize laboratory work. The more radical of this group would entirely eliminate science laboratories for high-school students. Although this point of view has gained some ground, further experience and investigations are necessary to establish this position; and we are not yet justified in omitting science laboratories from plans of proposed high-school buildings.

Curtis (268, 269) has made two reports on studies in the field of science teaching. His first volume reports selected studies made in science teaching over a twenty-year period, with emphasis on the investigations conducted from 1920 to 1925. The second volume is more selective and more recent. These digests have important implications for equipment planning, because of the investigations reported on science teaching by the lecture, demonstration, and laboratory methods.

Holy and Sutton (298) reported on the necessary apparatus for teaching the four high-school subjects, biology, chemistry, general science, and physics, together with estimated costs. The items in each of these were taken from published state department lists and leading science textbooks and laboratory manuals. The lists so made up were then submitted to 1,029 outstanding science teachers in thirty-five states for classification under three heads: necessary, desirable, and unnecessary. The final lists were then made from the 817 usable replies received.

Additional titles have appeared in recent issues of scientific journals (244, 246, 257, 275, 295, 302, 304, 312, 321, 322, 323, 324, 354, 356).

Industrial Arts Equipment

There is probably as large a volume of literature pertaining to industrial arts equipment as to any of the other special subject fields, as this field is of recent development and the authorities are not at all agreed on the purposes, methods, and contents of industrial arts departments. The general field of industrial arts may be divided into many special fields requiring a large number of shops with highly specialized equipment. However, the average small school cannot justify a number of special shops which show a very low degree of utilization.

The most common types of industrial arts courses are mechanical drawing and woodworking. More recently the general shop has become popular, especially in junior high schools. The general shops usually include equipment for bench woodworking, sheet metal work, electrical work, and very often other building trades. Another popular type of shop is the farm

shop for vocational agriculture. Auto-mechanic shops and printing shops have materially increased during recent years in the larger high schools.

In the various industrial shops there is a tendency to install multiple-use equipment. Individual electric motors assembled with power equipment have largely replaced the old method of power application through a common shaft. Greater attention is being given to safety devices in connection with industrial arts power equipment. As in the field of physical science, industrial arts literature contains worthwhile suggestions for home-made equipment, thus making the departments more instructive, practical, and economical. The bibliography contains many titles relating to equipment and apparatus for industrial arts shops (253, 254, 255, 267, 277, 278, 300, 309, 325, 341, 351).

Library Equipment[1]

Probably no division of the school has increased so rapidly in popularity as has the library. With a trend toward the elimination of high-school study halls, there has been a demand for larger library reading rooms. Instead of a reading room capacity of 8 or 10 percent of the high-school enrolment, the modern demand is for a reading room capacity of 15 or 18 percent. Wall shelves have largely replaced stack rooms, and there is some tendency to use reading tables with pupils facing only two ways instead of the old four-way tables where some of the pupils were forced to read while facing windows. More attention is being given to posture chairs for libraries, but there is yet a need for more education along this line.

Elementary-school libraries are increasing in number. There is a division of opinion as to whether the elementary-school library should be centralized or distributed in the various rooms. However, the tendency seems to be to provide and equip a central library of approximately classroom size, then to charge out as many books as the teachers wish in their rooms over a period of time for which the books are actually needed. In the modern elementary-school classroom there will be found a reading corner equipped with table and book shelves (271). Fargo (280) has contributed to literature in the field of school library equipment. Tilton (345) has discussed standard practices in this field.

Picture and Sound Equipment

Charts and pianos have been standard school equipment for many years. Then came lantern slides and talking machines. Now there has been added to these sensory aids the motion picture and radio. It is probably only a question of time until schools will have pictures combined with sound by

[1] Information and suggestions pertaining to library equipment are available through the *Wilson Bulletin for Librarians* (950-72 University Avenue, New York City), the *Library Journal* (62 West 45th Street, New York City), and the American Library Association (520 North Michigan Avenue, Chicago, Illinois).

wire and radio as they now have sound combined with pictures by the synchronized film and sound record. No modern classroom is complete, even now, without its loud speaker and electrical receptacle for a projection and motion picture machine.

Blom's study (258) and articles by Brownell (263), Funkhouser (287), and Jarvis (303) have suggestions regarding installation and use of radio equipment. Arnspiger (247), Brown (261, 262), Dorris (274), Finegan (282), Gould (289), Hollinger (297), Johnson and Clark (305), Morgan (326), C. Smith (338), and others (284, 349) dealt with the installation and use of motion picture equipment and other visual aids.

Stage Equipment

Correspondence and conferences by the author with the manufacturers of stage equipment revealed a few noteworthy trends. There is an increased demand for a stage loft, or high-ceiling stage, which will permit the use of drops. There seems to be a trend away from the requirement of the asbestos curtain except in the very largest high-school auditoriums. The necessity for asbestos curtains has been minimized by the modern method of flame-proofing stage curtains. There seems to be a tendency for dramatic instructors to favor the use of cycloramas instead of painted scenery, although painted scenes are still popular. The old type painted front drop has been almost entirely replaced by velour or rep curtains which operate on tracks. Suggestions as to the equipment necessary for a school theater will be found in a study by M. Smith (339).

Maps

For many years practically all geography and history maps were "politically colored," that is, political states and subdivisions of states were represented in different colors. The politically colored maps are still on the market and in common use; however, it seems that they are gradually being replaced by the "physically colored" maps, which indicate various altitudes by different colors.

There is some demand for maps mounted on cardboard and also the folding map mounted on vellum fabric; however, the manufacturers of maps indicate that practically the entire demand for maps today is for the spring-roller type. The closed map case containing a group of maps mounted on spring rollers is decreasing in popularity. This type of map case is being largely replaced with the open case with each map protected with a dust-proof strip at the bottom. The removable feature is becoming quite popular as it allows two maps to be compared side by side. There is also a demand, especially in the larger cities, for the individually mounted roller maps.

Classroom globes are usually either 12 or 18 inches in diameter. However, there is some advantage in the 16-inch globe which has recently been developed, as this type of globe gives an even scale of five hundred miles to an inch.

Purchase of Equipment

There are many current practices regarding the purchase of equipment. Loomis (313) has an objective-study technic for establishing school equipment costs. Schmidt (334) discussed the purchase of equipment.

The Survey by the United States Department of Commerce (347) indicates that 13.35 percent of the net sales of public seating goes for sales expense and advertising. This report also indicates that 41 percent of all public seating sold is purchased by schools, that 40 percent goes to theaters, 18 percent to churches, and that all the other outlets consume only 1 percent of the total output of public seating.

Another important fact shown by the Department of Commerce report is the seasonality of sales. Chart I shows the piling up of seating shipments during the month of August. It may be noted from the accompanying charts that other industries do not have such abrupt seasonal demands. This condition naturally makes for inefficiency in the seating industry, and is a serious charge against public-school administrators as they are primarily responsible for this situation.

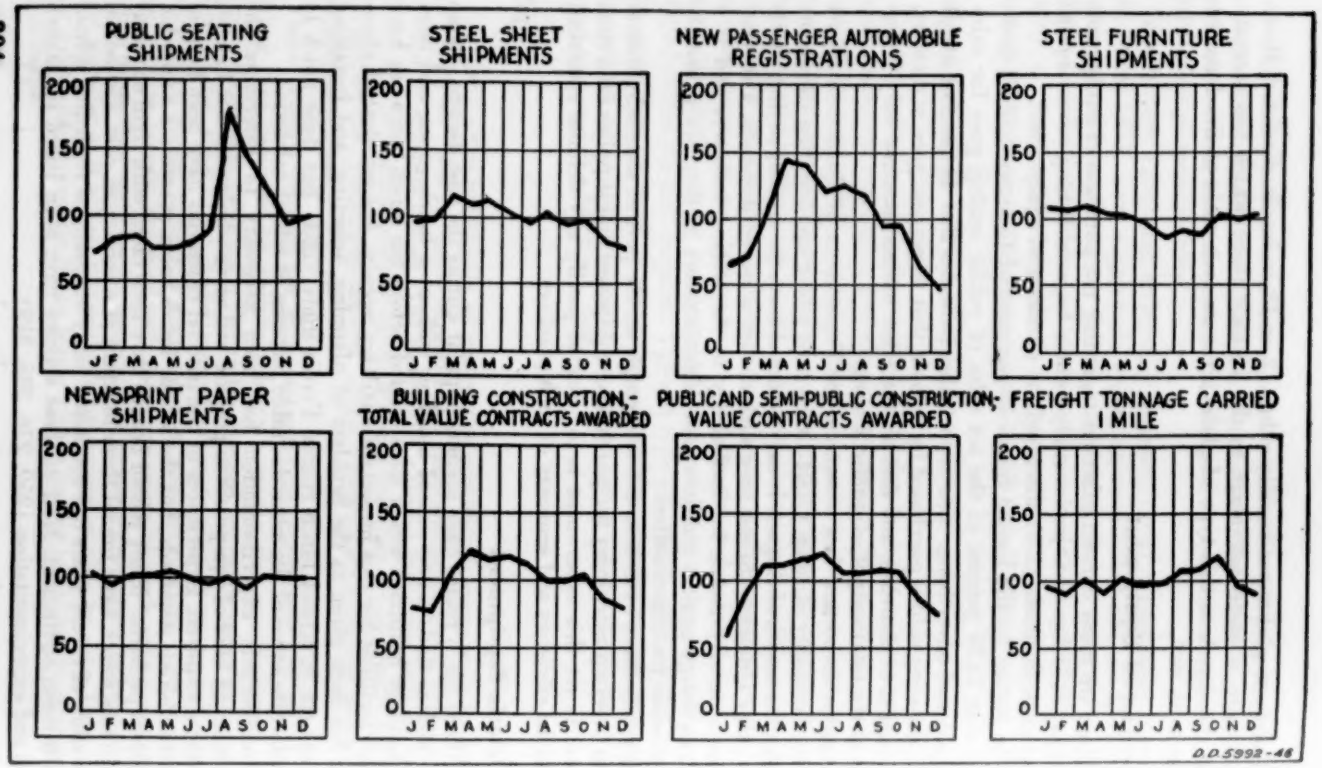
Recently there have been a few attempts on the part of state administrations to set up machinery for purchasing equipment and supplies on a state basis. As yet this experiment is too new to justify any definite statement as to the efficiency and economy of such practices.

Cafeteria Equipment

School lunch rooms have become popular during the past decade. Today one seldom finds a new school building without a lunch room, and most of the older buildings which were erected before the lunch room era have added facilities for this important auxiliary agency. A great deal of attention has been given to the problem of planning, selecting, and installing equipment in school lunch rooms. Ford's study (283) has done much to standardize some of the more desirable features of school cafeterias.

Considerable experimentation has been necessary to determine the amount and kind of equipment to prepare and serve wholesome hot lunches to school children. Experiences of commercial cafeterias have been helpful in establishing standards, but the school lunch room presents a somewhat different problem. Many school boards have been faced with rigid economy programs which have forced them to equip at a minimum cost. Periodical literature of recent years has contained many suggestions regarding school lunch room equipment. Most of these articles have been based on experience and experimentation (259, 276, 285, 319).

CHART I.—SEASONALITY OF SALES OF PUBLIC SEATING INDUSTRY CONTRASTED WITH OTHER INDUSTRIES, BASED ON MONTHLY AVERAGES 1927-29.



(Produced by permission from *Operations and Recent Trends in the Public Seating Industry*, U. S. Department of Commerce, Bureau of Foreign and Domestic Commerce.)

Office Equipment

With the development of administrative technic has come the demand for more and better equipment for school executives' offices. The modern school system must keep a system of pupil, teacher, financial, and property records which require carefully planned office equipment consisting of desks, files, and machines (266). The professionalizing of the principalship has made it necessary to equip principals' offices in both elementary and high schools with equipment for handling voluminous records of the pupils' curricular and extra-curricular activities (264).

Commercial education has brought business equipment into the schools as a part of the instructional furniture. Schools have taken over many articles of office equipment which are standard in the business world. Thau (343) made a study of office equipment used in school and in commercial practice. Many office equipment designs have been developed to serve the specific functions of the departments of commercial education (252, 270, 310). There has been a pronounced trend toward the use of calculating machines in school administration, in business, and in business education (307, 308, 352).

Physical Education Equipment

The results of the physical examinations of the men for World War service served to increase the emphasis on space and equipment for health and physical education. The proper equipment for play has become a subject for scientific research (290, 317, 336, 359). Most state departments of education have requirements and suggestions regarding playground equipment. Several states have issued bulletins on this subject. Michigan issued such a bulletin by Westphal (355) on home-made equipment and apparatus. Hunt (299) prepared a catalog of play equipment. Periodicals for the past few years also carried suggestions regarding equipment for physical education (265, 279, 281, 306, 318, 331). Some of these articles have dealt specifically with equipment problems connected with the school gymnasium (327, 346).

Fine Arts Equipment

Occasionally someone voices the prophecy that America is on the threshold of an artistic epoch. Certainly there has been some trend toward music and art education in our public schools. Simple textbook methods have been replaced or supplemented by equipment which will stimulate appreciation and give opportunity for creative self-expression. In addition to the piano, talking machine, and radio, there has been a considerable movement toward familiarizing boys and girls with musical instruments of the band and orchestra. The National Conference of Music Supervisors (250, 332, 337) has done much to popularize the use of musical instruments in

schools. The University of Nebraska issued a bulletin on home-made musical instruments by Weidemann and Weidemann (353). Educational periodicals have contributed to the literature on making and using musical instruments in the school (291, 292, 328). The equipment of art rooms has also been studied (350, 358).

Vandemark (348) made an experimental study to determine the types of pictures in which children are most interested.

CHAPTER V

School Supplies[1]

Definition and Classification of Supplies

As suggested in the Portland Survey (383) supplies used for school purposes may be defined as those commodities which are consumed during the course of a school year. Thus they are differentiated from school equipment, with which they are often associated and confused. Supplies are consumed by use during the year. Equipment, with care, is used over and over again year after year.

According to the St. Louis Survey (408) school supplies may be classified as (a) educational supplies, or those contributing directly to the work of instruction; and (b) operating and maintenance supplies, those contributing indirectly to the work of instruction. A more satisfactory classification of supplies includes three major categories: (a) administrative supplies, (b) instructional supplies, and (c) janitorial-engineering supplies.

Control of School Supplies

Current practices in the control of school supplies—The control of school supplies was treated by Ayres (364), Barr (366), Bobbitt (370), Claxton (378), Cooper (381), Cubberley (384), Hanus and Cummings (400), Judd (408), Strayer (465), and Anderson, Fowlkes, and Jones (361). At present, control of school supplies is vested in a number of different agencies. Some of these controlling agencies are (a) the superintendent, who usually has direct control in the smaller communities and supervisory control in the larger municipalities; (b) principals in larger educational organizations and also in smaller one-unit systems; (c) teachers, departmental heads, supervisors, and committees of teachers; (d) school boards, committees of school board members, and secretaries of boards of education; (e) business managers or assistant superintendents who are in charge of special fields; (f) janitors, primarily for building maintenance needs; and (g) clerks and other miscellaneous individuals and groups.

In addition to the writers already mentioned, the best agency for the control of supplies was treated by Fowlkes (396), Nash (425), Peel (434, 436), Judd (408) and others (454, 473). Professional educators as a body strongly favor fiscal independence. However, it is believed that the exact form of supply control must depend somewhat upon the individual community. It seems evident that whenever possible a special office for the administration of supplies should be established. Since the superintendent of any school system is held accountable for the success of his administra-

[1] Acknowledgment is made to Harold P. Brandenhoff and Fred Sauger for their assistance in connection with the compilation of the bibliography.

tion, he, rather than any other agency, should administer school supplies. Supplies are furnished for the development of increased educational offerings. In fields that require special capabilities, it is necessary in many school organizations for the superintendent to delegate authority to staff members. School officials engaged in special activities of this nature generally recognize that their efforts in the direction and control of supplies should operate "with minimum regard for immediate expediency and a maximum attention to high educational standards and service" (452: 66).

Control of supplies in fiscally dependent cities—As shown by Cooper (381), and Strayer (466, 468), in fiscally dependent cities various methods of control are exercised through power of review and control of submitted budgets. Buffalo, New York, furnishes a good example of the control of supplies under fiscal dependence. Total estimates of the board of education based upon estimates made by the board, the superintendent, the assistant superintendent of the supply budget, principals, departmental heads, and supervisors, are sent to the mayor and later to the council. The estimates are subject to revision by both of these latter agencies.

The controlling influence of the budget—The influence of the budget as a control of school supplies was demonstrated by Grill and Ulrich (399), Fowlkes (395), Moehlman (419), Pittenger (438), Bobbitt (370), Anderson, Fowlkes, and Jones (361), and Moran (422). Wise adherence to a budget, but not a slavish adherence to the minute details, was strongly recommended. If the necessary accounting procedures are available, the budgetary estimates for an approaching year automatically act as a control of the quantity and expenditures for school supplies. In keeping with the recommendations of Richardson (448), and Schmidt (450), and others (452, 473), the control of supplies must be flexible enough so that emergencies may be met. In this regard the following principles should be kept in mind: (a) the amount of supplies must be sufficient to carry on work, (b) the cost must not exceed the ability of the community to pay, and (c) the educational results must warrant the continued expenditures. Adequate control of supplies predicated upon the assumptions suggested will produce greater efficiency both in educational procedure and in administrative policy (452).

School Supply Standards

One of the things most needed in connection with school supplies is a thorough listing and classification of school supplies out of which reliable standards may be developed. The need for school supply standards was stressed by Anderson and Fowlkes (360), Anderson (362), Brown (373), Fowlkes (396), Irons (403), Lovejoy (416), Mullan (423), Richardson (448), Taylor (472), and others (458, 460, 461, 473), as well as having been emphasized in practically all books dealing with the business management of schools and treatises on school finances.

Obviously, standards for school supplies should be based upon quality, quantity, and cost. Some of the larger cities, notably Minneapolis, Cleveland, Milwaukee, Buffalo, and Detroit, have developed standards in terms of their local needs and practices. Lists of supplies with various items classified according to use combined with complete specifications of each item should be available in any school organization regardless of its size. As is suggested in the St. Louis Survey (408), this may be accomplished by working through committees of teachers in the various departments of the schools and compiling the data derived therefrom. Comparison can be made with other representative systems from which first a tentative and then a permanent list can be formulated. Anderson and Fowlkes (360), Brown (373), Irons (403), Richardson (448), Wegner (476), Moehlman (419), Pittenger (438), Bobbitt (369), Jones (406), Moran (422), the National Association of Public School Business Officials (426), and the National School Supply Association (427) and others (459, 460, 461) contributed towards the standardization of school supplies. Lists of articles commonly classified as supplies were compiled by F. Engelhardt and von Borgersrode (388), Fowlkes (395), and Peel (435). Bobbitt (369) suggested the middle 50 percent of supply costs as the "zone of safety in establishing school supply standards."

As suggested by Fowlkes (396), and Anderson, Fowlkes, and Jones (361), and others (473), many of the problems confronting educators in the field of supplies come in the instructional division. The basic question concerns the policy which should be adopted in the matter of furnishing instructional supplies. Should school organizations furnish all, part, or none of the supplies that can be considered essential for an education? Current practice in this connection varies greatly. Theoretically, at least, it seems that school authorities should furnish all necessary instructional materials in providing public-school education. This point of view has often been taken from the standpoint of greater efficiency and ultimate economy, and is expressed in the writings of Clark and Fowlkes (376), Lovejoy (416), and Anderson, Fowlkes, and Jones (361). In some schools where supplies are not furnished by the school, the supplies are sold to the pupils. If supplies are sold by the school to the pupils, such sales should be on a service basis. The benefit of a policy under which a school sells supplies to pupils lies in the fact that the school buys in large quantities and may then sell to the pupils at relatively low prices.

At present, the percentage of current expenditures devoted to the purchase of school supplies is exceedingly varied, as was shown by Engelhardt and Engelhardt (393), Taylor (472), and Anderson, Fowlkes, and Jones (361). Taylor (472) showed variations in costs of educational supplies, per pupil in average daily attendance, ranging from $1.14 in one city to $4.64 in another. Other investigations, for example one by Anderson, Fowlkes, and Jones (361), illustrated like conditions in per capita costs.

Much work is needed in the construction of supply standards for both individual subjects and various size schools. In this connection, heating cost standards for schools in various latitudes are particularly needed.

The Selection of Supplies

Anderson (362), Brown (373), Fowlkes (396), Irons (403), Jollief (405), Kelty (409), Nash (425), Richardson (448), Schmidt (450), Judd (408), the National Association of Public School Business Officials (426), and others (375, 441, 443) considered the problem of the selection of supplies. As Richardson (448) indicated, selection of school supplies can logically be made upon several bases. These bases should be established by the answer to the following question: What standards are to be desired in the selection of supplies from the viewpoint of the administrator, the instructor, and pupil? The solution of the problem lies in determining the best type of material for increasing instructional activities and learning. Supplies should not be bought on the basis of low price alone. In selecting supplies the following facts should be considered: (a) purpose for which the article will be used, (b) quality of supplies, and (c) cost of supplies. A high standard of quality is economical inasmuch as poor products purchased for the purpose of immediate economy will ultimately prove expensive. The amount of supplies bought should be based on amounts used during the previous three years. Because of wide variations in the cost of many commodities supposedly rendering the same service, complete specifications are of first importance. Proper specifications of supplies to be purchased derived from standard lists of supplies based on curriculum analyses will (a) improve the quality of supplies purchased, (b) guarantee greater economy and efficiency, and (c) facilitate the establishment of sound quantity standards. The selection of supplies should be made through a single purchasing agency and not through several agencies within an organization.

Ordering School Supplies

The problem of ordering school supplies was treated by Anderson (362), Buckalew (374), Clark and Fowlkes (376), Grill and Ulrich (399), Lovejoy (416), Moehlman (418), Nash (425), Rice (446), Simley (455), Ayres (364), Cooper (381), Judd (407, 408), Strayer (464, 466), and Anderson, Fowlkes, and Jones (361), and others (371, 452, 473). Present practices in the time of ordering, amounts ordered, and ordering routine present a story of conflicting procedure. Many school organizations do not order their supplies until late summer or early fall. As Clark and Fowlkes (376) and the National School Supply Association (427) showed, during the month of September the cost of supplies is generally higher than other months because of the large number of orders that are placed in September, thus producing an uneven manufacturing and shipping program for the

manufacturers of school supplies. As was shown by Clark and Fowlkes (376) and Ayres (364), time of ordering has a definite relationship to the cost of supplies. Inasmuch as per pupil cost of supplies can be determined with some degree of accuracy on the basis of index numbers, it would seem that educational administrators are obligated to formulate ordering policies which will reduce seasonal loads to a minimum (376).

School officials disagree as to the quantity of supplies that should be ordered in advance. Some believe that supplies should be ordered for the entire school year, stored at delivery in a central warehouse, and distributed during the school year. Others believe that supplies should be purchased for intervals covering varying periods of time. Variations as to practice in the amount of supplies ordered are determined somewhat by size of community, storage facilities, and the service that can be provided by supply firms. Adjustment of policy must be made to care for individual communities. It is rather generally recommended that supply needs for the following year be determined not later than April of the previous year. As has already been indicated, complete specifications of the necessary amount should be formulated. These should then be submitted to supply firms and bids obtained. As Anderson (362) pointed out, for large order buying samples should be requested. Acceptance of bids from vendors should be on the basis of (a) the price submitted, (b) the agreement of supplies with specifications demanded, (c) the service vendor can render, (d) the reputation of the supply house as a business institution serving educational needs. In asking bids from vendors, especially for purchase of quantity and where large amounts of funds are involved, the form of bid should be *specific* and not *blanket*. Supply houses should be asked to submit bids covering the individual order units, not merely the total amount involved.

Generally, it is more economical to order supplies in large amounts than it is to purchase the same articles in small quantities from time to time during the course of the school year. If storage space is small and it is not deemed advisable to carry a full year's amount of supplies in stock, arrangements with supply firms can be made that will allow orders to be filled through several deliveries rather than a single delivery (446).

According to R. W. Hibbert, "the planning, estimating, sampling, awarding of contracts, placing of orders, handling of supplies, and accounting entails an enormous amount of work which can be carried on economically only by carefully standardizing the articles bought and systematizing the routine" (452: 66). Ease in the selection, order, and purchase of school supplies by the administrator in charge is attained only if a systematic and business-like organization has been perfected.

The question often arises as to whether supplies should be purchased from local markets (455). The answer is in the affirmative, if the local dealer can meet the requirements and principles that have been previously

stated. Local supply firms should not, merely because of their location, expect orders predicated on a theory of higher prices or greater profits. Administrators should remember that constant effort must be exerted to make sure that the greatest possible value is being received for each dollar spent.

Delivery and Storage of Supplies

Jackman (404), Lehrbach (412), Peel (436), Monroe (421), Strayer (463), and others (442, 473) have written on the storage of school supplies. The policy adopted concerning the delivery and storage of supplies is closely connected with the problem of distribution of supplies within a school system and is extremely important. The advisability of delivery to (a) a central storehouse, (b) a sub-storehouse, and (c) direct shipment to individual schools should be considered (436). Two general types of storage are commonly found: (a) the central storeroom system, and (b) separate storerooms. Advantages and disadvantages have been found by users of each of these schemes. For example, one school system breaks away from a centralized control of school stores, and another is beginning a policy of centralized stores. According to Peel (436) each is prepared to give adequate reasons for its policy. Some authorities, such as Lehrbach (412) and Peel (436), favor central depositories, while other men, such as Taylor (472) and Hanus and Cummings (400), tend to favor storage by individual schools, including direct shipment. However, as Peel (436) pointed out, "direct shipments to many schools and units is a practice fraught with concealed dangers." For administrators interested in this problem, Peel set forth common plans of stores control that can be applied to any school system. He stated that for very large school systems substations appear to facilitate distribution. Lehrbach (412) pointed out that large quantities of supplies may be stored in order to obtain greater efficiency and economy. According to Peel (436), Monroe (421), and others (442) a central storehouse appears to be the best arrangement for all practical purposes for the average type of school organization. Despite the advantages of a central storeroom, it is easily possible that centralized storage may be more expensive than unit stores if the stores are handled in an efficient manner. Care should be taken not to go to extremes in connection with office routine in handling school supplies. A central store for a small school organization is often impractical because of the increased cost of overhead. In providing storage facilities, the recommendations of Jackman (404) and Strayer (463) might well be observed. Each storehouse of school supplies should have (a) sufficient space for storage of school supplies for a school year, (b) good lighting and accessibility, (c) good equipment of shelves and bins, arranged for efficiency and economy, (d) good protection from fire and theft, and (e) supervision by one person.

Payment for Supplies

As Lovejoy (415) and Cooper (381) clearly showed, adequate precautions should be taken by school authorities to insure care, regularity, and accuracy in the auditing and payment of all claims concerning supplies charged against them. The routine of auditing, checking the validity of the claim, and the payment of that claim should be systematic and expeditious. It is a reflection on the business procedure of many schools that just claims are neglected and payment is delayed for unwarranted lengths of time. Bills should be paid promptly, not merely because this promptness sometimes makes possible a trade discount, but because it is a sound policy and in keeping with good business methods. Contracts should not be consummated unless bills can be paid when due. For the school year (1929-30) Buffalo saved approximately $8,000 by taking advantage of trade discounts (381: 98).

The payment of a claim should follow an established procedure. When a bill is received the following questions should be answered: (a) Is the claim for contracted supplies that have been received? (b) Do the supplies meet with specifications and were they intact as per order? (c) Were supplies received in good condition and undamaged? When these questions have been answered in the affirmative, the validity of the claim is certain. Notice to this effect can then be mailed to the supply firm acknowledging such claim and assurance given that payment will be made at a specified date. A voucher can then be executed, with its accompanying entry of the transaction in the voucher register, and necessary steps for payment can be taken. The acceptance of a claim by a school is an acknowledgment of liability which should immediately make it a charge against remaining appropriations. Therefore, as soon as a claim is received and checked, it should be recorded at once for the purpose of insuring entry against its proper account. Whether or not the bill is paid immediately, in correct accounting procedure, the charge has been incurred and as such should be recorded (394, 395, 435).

Requisitioning and Distribution of School Supplies

Practices differ with respect to the requisitioning of school supplies and their distribution from storage to consumption points within a school system. All manner of plans exist, from that of no regular procedure to one in which routine and system have become a fetish. In the smaller school systems particularly, a middle course should be adopted with respect to the scheme of requisitioning and distribution. Supplies should never be delivered or distributed except upon requisition. Requisitions represent a formal request for supplies, and as Fowlkes (395), Peel (435), and Taylor (472) indicated, may be written in quadruplicate, triplicate, or duplicate. As Lehrbach (412), Lovejoy (414), Cooper (381), Hanus and Cummings

(400), Monroe (421), and Strayer (463) pointed out, the form of requisition most desirable is largely dependent upon the size of the system and the type of administrative control exercised. A requisition issued in quadruplicate may be of use in the following ways: (a) to act as a request for supplies, (b) to enable the supply clerk to maintain a cumulative record, (c) to make stock control possible, and (d) to serve as a basis for unit costs. The following procedure may be used in handling a requisition: (a) quadruplicate copy retained in school file; (b) original copy of requisition retained in superintendent's file, duplicate and triplicate copies sent to storehouse; (c) requisition filled, duplicate copy turned over to bookkeeper, and the triplicate retained by the storekeeper (435, 445, 472). In like manner, adequate use could be made of requisitions in triplicate, especially for small units in the distribution of supplies (444, 456).

The cost involved in the distribution and administration of supplies may be a considerable sum. One factor which may increase cost of supply administration unnecessarily is the frequency with which delivery from the central warehouse to the individual schools is made (385, 462). Authorities differ as to the optimum frequency of distribution as may be observed from the writings of Lovejoy (414) and Peel (436). According to Smith (456), supplies are distributed from periods varying from one year to distribution whenever school supplies are needed. It is difficult to set a hard and fast rule inasmuch as unusual circumstances should modify the policy. The number of deliveries should be kept to a minimum; but, on the other hand, delivery of supplies must be frequent enough so that the work of the school is not handicapped. It is extremely precarious to attempt to furnish supplies on a "hand to mouth" basis (464). Distribution of supplies can be controlled by formulating the allotment per pupil in average daily attendance. As Lovejoy (414) showed, special consideration must be given to special departments in connection with the distribution of supplies.

Accounting for School Supplies

As is indicated in the St. Louis Survey (408), the accounting for school supplies can be divided into two parts: (1) clerical routine and (2) cost accounting. Clerical routine includes (a) handling requisitions, including prices for accounting distribution; (b) recording receipts and delivery; (c) maintaining storage records and other miscellaneous functions. Cost accounting furnishes the basis for budget estimates, distribution control, and standards. A system of cost accounting for supplies should be provided for permanent and cumulative inventories of supplies. A definite system of charges against buildings, departments, and appropriations which will make possible the computation of specific unit costs should be included. Again, as indicated in the St. Louis Survey (408), these costs should show: (a) the cost of supplies for typical classes per pupil in average daily attendence; (b) the cost of supplies for typical classes per teacher; and

(c) supply costs by buildings. As Peel (435) demonstrated, the purpose of cost accounting is to compare costs so that either the quality of work will be improved or costs will be reduced.

For accounting procedures that can be adapted to various school systems in whole or in part, it is recommended that those interested read the following references: F. Engelhardt and von Borgersrode (388), Engelhardt and Engelhardt (392, 393), Fowlkes (395), Peel (435), Rainey (444), Smith (456), Taylor (472), Judd (408), and Strayer (470).

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Chapter II. The School Site

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ERRATA IN VOLUME II

The following errata have been called to the attention of the Editorial Board by those whose names appear in parentheses and have been approved by the Chairman of the Editorial Board and the author of the chapter concerned.

The writer desires to correct some errors in his summary "Physical and Biological Sciences" published in the issue of February, 1932. On page 23 it is stated that "Hurd (79, 1925-26) conducted an experiment with the project in high-school physics; and while his conclusions favored the project method his data might, with considerable justification, be given an interpretation in favor of the assignment method."

Page 23 Under 79 in the bibliography three reports are referred to. The statement quoted does not do justice to the first of these reports. The study of the relative values of the topical and problem methods does not classify as an investigation of the project versus the assignment methods, and the conclusion favors the topical rather than the problem method. In "Subject Matter Versus Character Traits" the author concludes that the assignment method did result in higher conventional achievement.

Page 27 On page 27 it is pointed out that two conclusions (77, 1929) and (78, 1929) are in opposition. No recognition is given that Hurd recognized the serious limitations of the former. (Max D. Engelhart, Bureau of Educational Research, University of Illinois)

Page 217 In Volume II, No. 3, "Tests of Personality and Character," page 217, the publisher of the *V. I. Q. Booklets* (*Hepner*) is given as *Stoelting*; whereas the Psychological Corporation is the publisher, copyright owner, and sole distributor of these booklets. (Paul S. Achilles, Secretary and Treasurer, Psychological Corporation)

INDEX TO VOLUME II

Future topics of the

Review of Educational Research

1. Methods and Technics of Educational Research
2. The Curriculum
3. Teacher Personnel
4. School Organization
5. Special Methods (at all levels)
6. Psychology of Learning (including psychology of the school subjects)
7. Finance and Business Administration
8. Psychological Tests
9. Buildings, Grounds, Equipment, and Supplies
10. Educational Tests
11. Mental and Physical Development and Individual Differences
12. Student Accounting, Personnel, and Guidance
13. General Methods and Supervision
14. History of Education and Comparative Education
15. Legal Basis of Education